595

AMERICAN JOURNAL
OF
PHYSICAL ANTHROPOLOGY

Founded by Aleš Hrdlička, 1918

MANAGING EDITOR

WILLIAM S. LAUGHLIN
University of Wisconsin

ASSOCIATE EDITORS

MARSHALL T. NEWMAN
U. S. National Museum

WILLIAM C. BOYD
Boston University
School of Medicine

MELVIN L. MOSS
Columbia University

J. LAWRENCE ANGEL
Jefferson Medical College

BOOK REVIEW EDITOR

FREDERICK S. HULSE
University of Arizona

Official Organ of the American Association of Physical Anthropologists

NEW SERIES — VOLUME 18
MARCH, JUNE, SEPTEMBER,
DECEMBER, 1960

PUBLISHED BY

THE WISTAR INSTITUTE OF ANATOMY AND BIOLOGY
PHILADELPHIA, PA.

CONTENTS

No. 1 MARCH 1960

FRANK B. LIVINGSTONE, HENRY GERSHOWITZ, ESTHER BACON, FRANKLIN J. KELLER AND ABNER R. ROBINSON. The Blood Groups, Abnormal Hemoglobins, and Hemoglobin Values of Pregnant Women in Liberia 1

D. F. ROBERTS, H. LEHMANN AND A. E. BOYO. Abnormal Hemoglobins in Bornu 5

CHARLES R. NOBACK, MELVIN L. MOSS AND ELIZABETH LESZCZYNSKA. Digital Epiphyseal Fusion of the Hand in Adolescence: A Longitudinal Study 13

WILLIAM MONTAGNA AND RICHARD A. ELLIS. The Skin of Primates. II. The Skin of the Slender Loris (*Loris tardigradus*) 19

MARSHALL T. NEWMAN. Populational Analysis of Finger and Palm Prints in Highland and Lowland Maya Indians ... 45

WILLIAM D. HOHENTHAL AND SHEILAGH THOMPSON BROOKS. An Archaeological Scaphocephal from California 59

Brief Communications:

WILLIAM MONTAGNA AND RICHARD A. ELLIS. Histology and Cytochemistry of Human Skin. XXI. The Nerves Around the Axillary Apocrine Glands 69

MELVIN L. MOSS. A Reevaluation of the Dental Status and Chronological Age of the Tepexpan Remains 71

Book Reviews:

JACQUES M. MAY. The Ecology of Human Disease. *Reviewed by* Frank B. Livingstone 73

A. E. MOURANT, ADA C. KOPEC AND KAZIMIERA DOMANIEWSKO-SOBCZAK. The ABO Blood Groups. *Reviewed by* Joseph B. Birdsell 75

No. 2 JUNE 1960

W. K. Chagula. The Age at Eruption of Third Permanent Molars in Male East Africans 77

W. K. Chagula. The Cusps on the Mandibular Molars of East Africans 83

R. I. Spearman and N. A. Barnicot. A Study of the Bilaterality of Human Hair 91

C. A. Erskine and C. C. C. O'Morchoe. Measurement and Surface Features of the Cranial Fossae in Closed Skulls 97

R. T. Simmons, D. C. Gajdusek and Lois C. Larkin. A Blood Group Genetical Survey in New Britain 101

Fred H. Allen, Jr., and Patricia A. Corcoran. Blood Groups of the Penobscot Indians 109

Chong Duk Won, Han Su Shin, Suk Whan Kim, Jane Swanson and G. Albin Matson. Distribution of Hereditary Blood Factors Among Koreans Residing in Seoul, Korea 115

J. L. De Vries and L. E. Nijenhuis. Blood Group Frequencies in New Guinea. I. The Sentani Papuans 125

M. Layrisse, Z. Layrisse and J. Wilbert. Blood Group Antigens Among the Paraujano 131

Frederick S. Hulse. Ripples on a Gene-pool: The Shifting Frequencies of Blood-type Alleles Among the Indians of the Hupa Reservation 141

Brief Communication:

E. Lloyd DuBrul and Charles A. Reed. Skeletal Evidence of Speech? 153

Book Review:

Alexander Galloway. The Skeletal Remains of Bambandyanalo. *Reviewed by* Ashley Montagu 157

Books Received 159

CONTENTS

No. 3 SEPTEMBER 1960

FRANK B. LIVINGSTONE, HENRY GERSHOWITZ, JAMES V. NEEL, WOLF W. ZUELZER AND MARVIN D. SOLOMON. The Distribution of Several Blood Group Genes in Liberia, the Ivory Coast and Upper Volta 161

EDGAR J. MARTIN. Incidence of Bifidity and Related Rib Abnormalities in Samoans 179

L. E. NIJENHUIS, TH. BEKKERS AND J. L. DE VRIES. Blood Group Frequencies in New Guinea. II. The Blood Groups of the Asmat Papuans 189

L. E. NIJENHUIS AND J. L. DE VRIES. Blood Group Frequencies in New Guinea. III. Blood Groups of the Nimboran Papuans 193

E. MARGOLIS, J. GUREVITCH AND D. HERMONI. Blood Groups in Sephardic Jews 197

E. MARGOLIS, J. GUREVITCH AND D. HERMONI. Blood Groups in Ashkenazi Jews 201

SANTIAGO GENOVÉS T. Revaluation of Age, Stature and Sex of the Tepexpan Remains, Mexico 205

STANLEY M. GARN AND CHRISTABEL G. ROHMANN. Variability in the Order of Ossification of the Bony Centers of the Hand and Wrist 219

VIKING FUND MEDALIST FOR 1959. (WILLIAM W. GREULICH). By J. Lawrence Angel 231

Brief Communication

A. FREIRE-MAIA, N. FREIRE-MAIA AND A. QUELCE-SALGADO. Genetic Analysis in Russian Immigrants. PTC Sensitivity, Finger Prints, Color Vision, Hand Clasping, and Arm Folding 235

Book Reviews

STANLEY M. GARN AND ZVI SHAMIR. Methods for Research in Human Growth. *Reviewed by* Gabriel Ward Lasker 241

JOHN C. GREENE. The Death of Adam. *Reviewed by* Jack Kelso 242

CONTENTS

No. 4 DECEMBER 1960

Albert A. Dahlberg. The Dentition of the First Agriculturists (Jarmo, Iraq) 243

Gabriel W. Lasker. Variances of Bodily Measurements in the Offspring of Natives of and Immigrants to Three Peruvian Towns 257

Makoto Suzuki and Takuro Sakai. A Familial Study of Torus Palatinus and Torus Mandibularis 263

Robert Sheeran Benton and James Anderson Gavan. The Concept of Homology Applied to the Anterior Superior Iliac Spine 273

Melvin L. Moss and Richard W. Young. A Functional Approach to Craniology 281

Stanley M. Garn and Christabel G. Rohmann. The Number of Hand-Wrist Centers 293

Alexander S. Wiener and Eve B. Gordon. The Blood Groups of Chimpanzees. A-B-O Groups and M-N Types 301

L. J. Ray. Cranial Contours in the Australian Aboriginal 313

Book Reviews

Frederick P. Thieme. The Puerto Rican Population. A Study in Human Biology. *Reviewed by* Marshall T. Newman 321

V. V. Bunak, G. F. Debets and M. G. Levin. Contributions to the Physical Anthropology of the Soviet Union. *Reviewed by* Earl W. Count 322

E. Lloyd du Brul. Evolution of the Speech Apparatus. *Reviewed by* William L. Straus, Jr. 325

Proceedings of the Twenty-Seventh Annual Meeting of the American Association of Physical Anthropologists 327

Proceedings of the Twenty-Eighth Annual Meeting of the American Association of Physical Anthropologists 353

The Blood Groups, Abnormal Hemoglobins, and Hemoglobin Values of Pregnant Women in Liberia[1]

FRANK B. LIVINGSTONE,[2] HENRY GERSHOWITZ, ESTHER BACON, FRANKLIN J. KELLER AND ABNER R. ROBINSON

Department of Human Genetics, University of Michigan, Ann Arbor, Michigan, The Lutheran Mission Hospital, Zorzor, Liberia, and Child Research Center, Detroit, Michigan

During the course of a survey of the blood groups and abnormal hemoglobins of Liberia, we have examined the blood of 117 women attending an antenatal clinic at the Lutheran Mission Hospital, Zorzor, Liberia. The clinic was scheduled weekly, and the women were given iron and vitamin supplements at each attendance, which in some cases was irregular. The great majority of these women were in the 5th to 9th month of pregnancy; however, a more recent follow-up of these women by one of us (E.B.) has found that one was not pregnant and 4 others were stated to have aborted but could possibly not have been pregnant.

Zorzor is situated in the central interior of Liberia about 5 miles from the Guinea border. It is in the territory of the Loma tribe, but with the opening up of the country in recent years immigrants from other tribes have settled in the area. In addition to the Loma, who constitute the majority of our sample of pregnant women, two other tribes are represented, the Kpelle, who inhabit the country south of Zorzor, and the Mandingo, who have come into the area as cola nut farmers and traders from Guinea to the north.

METHODS

Blood was collected in 10 ml "Venules" containing oxalate on 4 and 5 June, 1958, packed in iced thermos jugs, and air-shipped to the Child Research Center, Detroit, Michigan, where the abnormal hemoglobins and hemoglobin values were determined. The blood grouping was done at the Department of Human Genetics of the University of Michigan on 12 and 13 June 1958. Red cell antigens are known to deteriorate, and during the past two years we have occasionally experienced this in blood samples from various parts of the world. However, considering the rather short interval between collection and testing, and also the fact that many of the results to be reported are consistent with our previous findings on these tribes, there appears to have been little loss of erythrocytic antigenic properties.

All typing sera were obtained from commercial sources, and the methods of testing were those described by the vendor of each particular serum. All tests were performed in tubes with 2% washed red cell suspensions. In order to conserve serum, a two-stage screening procedure was used for the Rh system. The samples were first tested with anti-C and anti-E, and only those positive for C were tested further with anti-c and anti-C^w (no positives for this antigen were found on the entire survey), while only those positive for E were tested with anti-e. The designation of D^u was made when a sample failed to react with saline anti-D but did react with a potent incomplete anti-D in the Coombs test.

RESULTS

The results, together with a control sample for the Kpelle and Loma, are shown on table 1. The sample of pregnant women from the Kpelle tribe totalled 11 and has been included with the Loma sample, since on the basis of larger numbers of tests, these tribes have not been significantly different for any blood group frequency. Included under "Others" on table 1 are

---

[1] This study was supported in part by Contract AT(11-1)-405 with the U. S. Atomic Energy Commission.

[2] National Science Foundation Postdoctoral Research Fellow.

TABLE 1

The blood groups, abnormal hemoglobins, and hemoglobin values of patients attending the clinics of the Lutheran Mission Hospital, Zorzor, Liberia

	Pregnant women		Others		Control for Kpelle-Loma
	Kpelle-Loma	Mandingo	Kpelle-Loma	Mandingo	
Number	100	17	17[1]	11	
Average hemoglobin value (gm %)	9.91	9.73	12.74	11.65	12.72
Hemoglobin pattern					
Number with AA	90	12	14	4	513
Number with AS	8	5	3	5	65(10.9%)
Number with AC	1	—	—	2	10(1.7%)
Number with SF	1	—	—	—	1(0.2%)
Number with AK	—	—	—	—	1(0.2%)
Number with AN	—	—	—	—	6(1.0%)
Blood groups					
Number with O	46	8	9	3	268(43.7%)
Number with A	22	6	3	4	165(26.9%)
Number with B	24	2	5	2	144(23.5%)
Number with AB	9	1	2	2	36(5.9%)
M	32	3	4	3	130(21.2%)
MN	37	6	12	6	296(48.3%)
N	31	8	3	2	187(30.5%)
ccDee	57	10	17	6	168(73.0%)
CcDee	10	2	1	1	28(12.2%)
CCDee	—	—	—	—	2
ccDEe	7	3	—	3	15(6.5%)
ccDEE	1	—	1	—	1
CcDEe	—	—	—	—	3
ccD^{u}ee	6	1	—	1	2 (2.6%)
CcD^{u}ee	1	—	—	—	4
ccddee	10	—	—	—	6 (3.0%)
Ccddee	5	1	—	—	—
ccddEe	3	—	—	—	1

[1] For this category 19 specimens were blood grouped, but hemoglobin determinations were done on only 17 due to the insufficiency of red cells for two samples.

blood samples obtained at the same time as those from the pregnant women, but from persons attending the outpatient clinic at the Lutheran Hospital. These are mostly adult males, but some adult females are also included. The control samples were obtained on various surveys throughout Liberia and contain individuals from all parts of the Kpelle and Loma tribal areas. Hence the control blood group frequencies are the mean frequencies for the entire Kpelle and Loma tribes. While the percentages of the various blood groups are shown for the controls, for the Kpelle and Loma pregnant women these percentages are the same as the actual numbers. It should also be noted that the differences in numbers of tests done on the controls for the various blood group antigens are due to our having begun testing for these antigens at different times during the course of our project.

DISCUSSION

The hemoglobin values, both for the pregnant women and the other adults, approximate but are slightly higher than those found by Woodruff and Schofield ('57) in the Gambia. These increases can perhaps be explained by the fact that in addition to the iron and vitamin supplements given to the pregnant women, most of our patients were treated for hookworm and malaria. In any case, both studies indicate that the stress of pregnancy results in a decrease of 2–3 gm of hemoglobin in West Africans living under similar conditions.

For the Kpelle and Loma pregnant women the frequencies of the sickle cell and hemoglobin C genes are similar to previously recorded tribial frequencies (Livingstone, '58; Neel et al., '56). For the Mandingo, however, the frequencies of the sickle cell gene, both among the pregnant women and the other patients from Zorzor, are quite high when compared to the average Mandingo frequency in Liberia (Livingstone, '58). The groups of Mandingo who have migrated into the Gambia also show great variability in their in their frequencies of the sickle cell gene (Allison, '56).

One Loma woman showed an SF pattern on paper electrophoresis. This is one of the diagnostic criteria of sickle cell anemia due to homozygosity for the sickle cell gene, but it is not sufficient evidence for this diagnosis (Edington and Lehmann, '55). We have also found several other individuals with this electrophoretic pattern who showed no other symptoms of anemia (Neel et al., '56). It is interesting to note in this respect that this woman has had 7 full-term pregnancies and one abortion. She complained of "weakness" after childbirth and had a hemoglobin value of 8 gm but otherwise appeared to be in normal health for a women of her age in this area. In view of the recent finding of an appreciable frequency of thalassemia in Liberia (Olesen et al., '59), we think it more likely that this woman is heterozygous for both the thalassemia and sickle cell genes.

The ABO blood group gene frequencies of the Kpelle and Loma pregnant women do not differ significantly from those of the controls ($\chi^2 = 0.570$, 2 d.f., $.75 < P < 0.90$), nor do the MN gene frequencies ($\chi^2 = 1.896$, 1 d.f., $.10 < P < 0.25$). However, the observed number of MN heterozygotes is much lower than the expected number in a Hardy-Weinberg equilibrium, and for the Kpelle and Loma pregnant women is statistically signficant ($\chi^2 = 6.756$, 1 d.f., $0.005 < P < 0.01$). Technical error might be suspected here, but it should be noted that the other blood samples which were taken at the same time as those of the pregnant women do not show this decrease in MN heterozygotes. In addition, only two of 34 tribal samples from Liberia of our survey show a similar deviation from expected. The decrease in MN heterozygotes seems to be apportioned equally among the MM and NN homozygotes, and this increase in homozygotes might possibly be due to inbreeding resulting from the size of the breeding isolate in this part of Liberia. On the other hand, it may be that the MN heterozygous women are not having as much difficulty in pregnancy and hence not as likely to attend the antenatal clinic.

If the Rh− phenotypes on table 1 are combined, the frequency of Rh− among the Kpelle and Loma pregnant women is 18%, while it is 3% among the controls. This difference is highly significant ($\chi^2 = 22.267$, 1 d.f., $P << 0.001$). Since the tribes of Liberia do not differ significantly in their Rh frequencies (Livingstone, et al., n.d.) and the average frequency of Rh− is slightly less than 5%, the greatly increased frequency among pregnant women seems to be a real difference and not a statistical artifact.

The finding of a greatly increased frequency of Rh− among pregnant women seems to be due to two reasons. The first and most obvious reason is that these women would be more likely to have difficulty in child-bearing and hence more likely to attend the antenatal clinic. The second reason is the result of the child-rearing practices of the Kpelle and Loma people. In these societies a woman's main task in life is to have as many children as posible. However, after a child is born, there are strict tabus against the mother becoming pregnant again before the child is weaned. For the Loma the mother must not cohabit with her husband until the child is three years old if it is a girl, or 4 years old if it is a boy (Schwab, '47; p. 209). Similar practices which attempt to "space" children are quite widespread among primitive peoples and are presumably efforts to give the child a maximum chance to survive. In such a society women with unsuccessful pregnancies would be almost continually pregnant, while those whose children lived would be pregnant once every 4 years at most. Since Rh− women would be more likely to have difficulty in child-rearing, these cultural practices of the Kpelle and Loma seem to

TABLE 2

Outcomes of present pregnancies

	No. of women	Full-term livebirth	Full-term stillbirth	Premature livebirth	Premature stillbirth	Abortion	Neonatal death
Rh—	18	14(77.8%)	–	2	2	–	2
Rh+	89	78(87.6%)	1	5	2	3	6

Histories of multigravida

	No. of women	Total conceptions	Abortions	Stillbirths	Livebirths	Children living	Children dead
Rh—	14	34	3	4	27	14	13
Rh+	68	232	28	24	180	118	62

be another factor increasing the frequency of Rh— women among the women pregnant at any one time.

In order to determine whether the foregoing explanation has any evidence in its favor, we have recorded the outcomes of these pregnancies where possible and attempted to obtain pregnancy histories from the multigravida. Table 2 shows the results of these inquires.

It is not difficult to envisage many biases in these data, and there has undoubtedly been some failure to recall previous pregnancies on the part of the multigravida. Nevertheless, the Kpelle and Loma women do remember quite accurately the number of livebirths they have had and, of course, the number who are still living. Thus, in the last two columns of the pregnancy histories there is some evidence to indicate that the Rh— women have had more difficulty raising viable offspring. The Rh— women have an average of 1.00 living children per woman, while the Rh+ women have 1.74, but this difference is not statistically significant ($\chi^2 = 1.908$, 1 d.f., $0.10 < P < 0.25$). There are few of the present pregnancy outcomes of the Rh— women which show direct evidence for Rh sensitization. Two of the live-births were jaundiced but recovered. Some of these women did show histories of repeated neonatal deaths or stillbirths, and the frequencies of neonatal deaths and stillbirths are somewhat higher for the Rh— women, but the numbers are too small to be of real significance. Thus, although there is some evidence for Rh sensitization, our data seem to indicate that other factors may also be involved in increasing the frequency of Rh— women among the women pregnant at any one time to 18% from its expected frequency of about 5%. Our results also indicate that Rh sensitization in pregnancy may be more of a medical problem in West Africa than was previously supposed, but a more accurate estimate of its frequency there will have to await the collection of more data on this problem.

Since submitting this manuscript we have tested the sera of the 19 Rh— women and none had demonstrable anti-D antibodies. This does not preclude the presence of anti-V.

LITERATURE CITED

Allison, A. C. 1956 The sickle-cell and haemoglobin C genes in some African populations. Ann. Human Genet., *21:* 67–89.

Edington, G. M., and H. Lehmann 1955 Expression of the sickle cell gene in Africa. Brit. Med. J., *2:* 1328.

Livingstone, F. B. 1958 The distribution of the sickle cell gene in Liberia. Am. J. Human Genet., *10:* 33–41.

Livingstone, F. B., H. Gershowitz, M. Solomon, G. Binson, W. W. Zuelzer and J. V. Neel n.d. The distribution of several blood group genes in Liberia, the Ivory Coast, and Upper Volta. In preparation.

Neel, J. V., J. Hiernaux, J. Linhard, A. R. Robinson, W. W. Zuelzer and F. B. Livingstone 1956 Data on the occurrence of hemoglobin C and other abnormal hemoglobins in some African populations. Am. J. Human Genet., *8:* 138–149.

Olesen, E. B., K. Olesen, F. B. Livingstone, F. Cohen, A. R. Robinson, W. W. Zuelzer and J. V. Neel 1959 Thalassemia in Liberia. Brit. Med. J., *1:* 1385–1387.

Schwab, G. 1947 Tribes of the Liberian Hinterland. Papers of the Peabody Museum of American Archaeology and Ethnology, Harvard Univ., Cambridge.

Woodruff, A. W., and F. D. Schofield 1957 Hemoglobin values among Gambians. Trans. Roy. Soc. Trop. Med. Hyg., *51:* 217–220.

bnormal Hemoglobins in Bornu

D. F. ROBERTS, H. LEHMANN AND A. E. BOYO

Department of Human Anatomy, University of Oxford, Department of Pathology, St. Bartholomew's Hospital, London, and Department of Chemical Pathology, University College, Ibadan

East-west movement across the northern assland belt of Africa has for centuries en channeled into the narrows between ke Chad and the northern tip of the meroons mountains, or through the wid- passage between Chad and the desert. th routes converge on Bornu, (fig. 1) rmerly one of the great empires of terior Africa, today an administrative ovince of northeast Nigeria which em- aces the northern Cameroons. Through rnu has passed a series of waves of in- ding and immigrant peoples, of different nic affinities, of different languages, ssessing different customs and ways of e. Some have settled in this vast plain scrub savana, differing locally in the gree of sandiness or availability of water t otherwise an essentially uniform hab- t. Each of the more recent waves of wcomers has retained something of its dividuality, to some extent its traditions, language, in one instance at least until ently its political autonomy. Traditions, cient documents, and the writings of rly Muslim travelers enable the periods which each immigration occurred to be ablished. Here it seemed was an area which investigations among the different oples might give some evidence on the e of change of the frequencies of the normal hemoglobin genes.

Of the groups investigated the Kanouri re the earliest established. Linguisti- ly akin to the Teda of Tibesti, they en- ed Bornu from Kanem in a series of ves in the 13th and 14th centuries, jugating the earlier inhabitants. To- y they are town and village dwellers ose economy is centered on agriculture. hough Kanouri is a name sometimes plied loosely to all Kanouri speaking in- bitants of Bornu, the present sample ers to those who call themselves Kanouri in contradistinction to the other groups of the area, e.g., the Kanembu and Kwoyam. The Shuwa Arabs began to enter Bornu from the east, from Darfur and Wadai, at the beginning of the 17th century, and they merged with the Kanouri and other previous inhabitants. In 1809 Shehu Laminu invited the Shuwa to help him drive the invading Fulani out of Bornu, and a second wave of Shuwa tribes entered from the east, were given lands and granted independence of Kanouri control; it is from these tribes that the present sample was drawn. Although a certain amount of cultivation is done, the Shuwa are much more dependent on pastoralism than the Kanouri, spending the wet season in their own small untidy villages and the dry season away at pasture. At the same period Shehu Laminu also invited Kanembu tribes from the east of Lake Chad into Bornu to support him; many subsequently intermarried with the Kanouri, but the Bedduwai, pastoral nomads, remained relatively unmixed and are still regarded as the purest of the Kanembu tribes. Although the Kanembu were originally distinct from the Kanouri, being established in Kanem before the arrival there of the latter, they are of the same language group and are considered by some to be of common stock. The Wakura and Hidkala, pagan tribes in the extreme southeast of Bornu, are representatives of the most recent movement into the plains, one that is still taking place, down from the mountains of the northern Cameroons. According to tradition the Wakura are one of the pagan peoples who settled in the mountains above Gwoza after moving from the ranges to the south (Adamawa) and east (Mandara), at a period which study of their genealogies suggests was well over 400 to 500 years ago, while the Hidkala

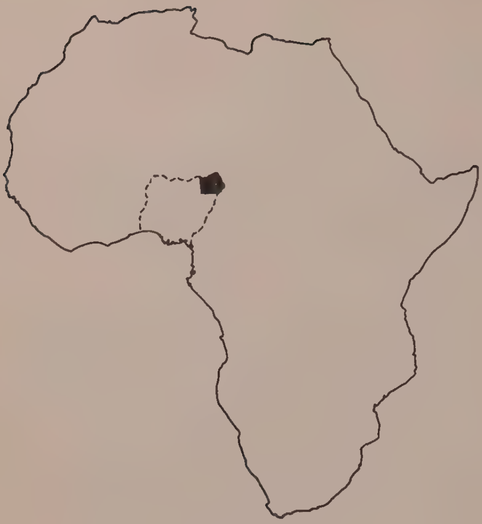


Figure 1

are a tribe made up of a collection of different groups who migrated into the Gwoza hills rather more recently. In the early days their mountain refuges served as protection against the continual slave raiding of the Mandara, and from the early 19th century until 1922 against the exactions of the Fulani. It is therefore only within the last few decades that conditions have been sufficiently stable to attract a proportion of these pagans down from their terrace cultivations of the mountains to the easier farming in the plains. The plainsward movement has proceeded farther amongst the Wakura who today are established around the foot of the Zeledeva spur at the extreme northern tip of the Cameroons mountains, than amongst the Hidkala, whose settlements still cluster in the valleys and along the foot of the range immediately to the south of Gwoza (fig. 2).

Blood specimens were obtained from 1009 individuals of both sexes who would have been going about their everyday affairs but for the presence of the investigators; all were adult except for 40 children (aged 5 to 18 years) whose inclusion made no perceptible difference to the phenotype frequencies observed. No close relatives and no individuals whose remembered ancestry showed intermixture with other peoples were included. The specimens from a random sample of adults from each of three peoples, Shuwa, Kanouri and Wakura, obtained in their ow villages, were dispatched to London, t gether with specimens from a sample c Bedduwai taken (on account of lack c time) in the prison at Maiduguri; a pr liminary report on the findings from thi part of the data has already appeare (Roberts and Lehmann, '59), From large samples of Shuwa, Kanouri and Wakur living in the villages covered by the forme specimens were sent to Ibadan, togethe with a sample of Hidkala. Investigatio was intentionally restricted to a distin and geographically identifiable segment each people. In the case of the Shuw sampling was based on the tribal and se tional structure and an area within radius of 30 miles east of Golumba w covered. For the Wakura and Hidkal sampling was based on lineage structur they were examined in their settlements r spectively in the plains around the foot the Zeledeva spur to the north of Gwo and along the foot of the hills over a di tance of some 10 miles to the south Gwoza. The Kanouri and Bedduwai sam ples were based on village of residenc the Kanouri were drawn from 116 villag between 20 and 60 miles, and the Be duwai from 63 villages between 40 ar 100 miles northwest of Maiduguri. Tl specimens were transmitted by air to Lo don or Ibadan where they were examin by electrophoresis on paper strips in ver cal tanks, using buffer solutions of pH 8 The runs in London were of 14 to 18 hou duration at 160 volts, and in Ibadan 10 to 12 hours duration at 230 volts in airconditioned room at a temperature 20°C. The specimens were also examin chemically for sickling: Itano's solubili test confirmed the presence of hemoglob S in three cases that failed to sickle b showed electrophoretically an AS patte

RESULTS

The results are presented in table 1; t phenotype frequencies in Kanouri, Shu and Wakura samples sent to Ibadan we closely similar to those observed in the Lo don samples, so for each people the resu are pooled.

The abnormal hemoglobins obser were S and C. AC phenotypes at a f quency of about 5% occur in both Waku

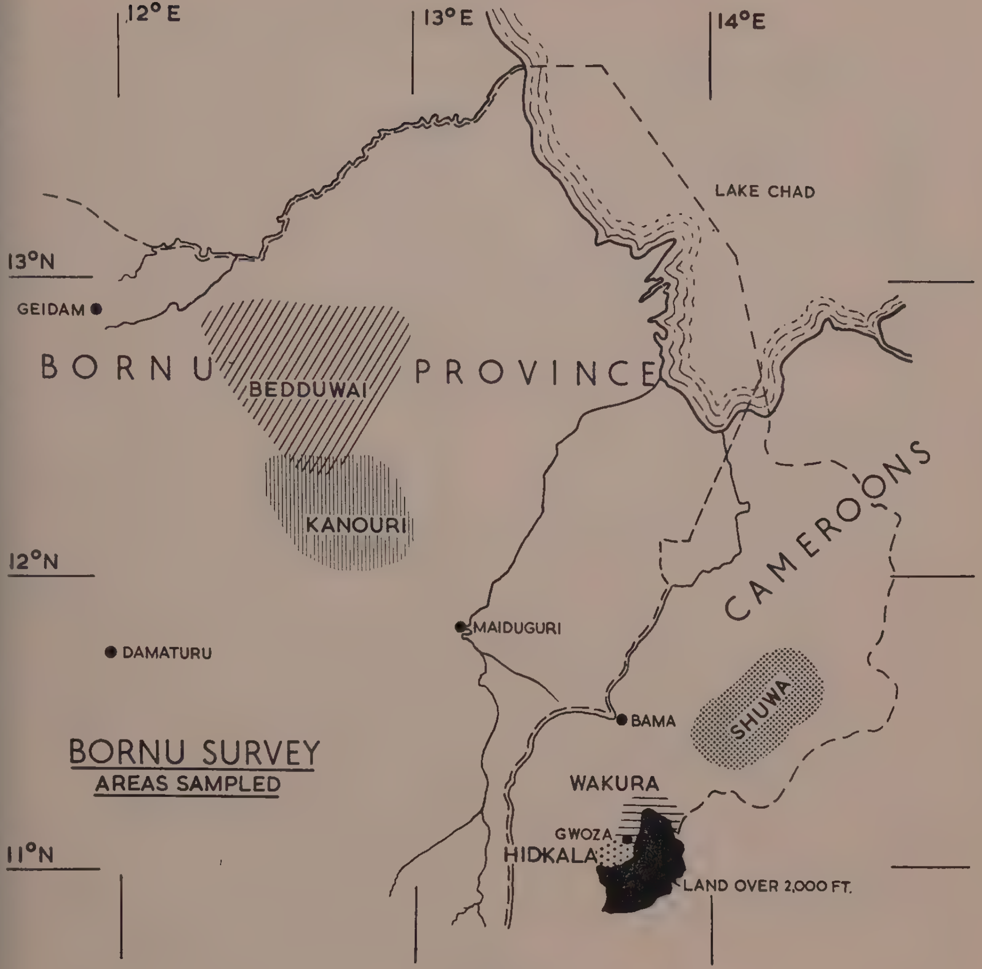


Figure 2

d Hidkala, and serve to distinguish
^{2} highly significant at 0.1%) these
voza pagans from the other three
oples, amongst whom the trait is present
ly at trace frequencies. AS phenotypes
e present at high frequency in the Bed-
wai and Kanouri—in the former higher
an in any other non-Bantu sample in
rica—and at somewhat lower frequen-
s in the other samples. The absence of
C homozygotes is not surprising in view
the heterozygote frequencies. The ab-
nce of SS homozygotes is however strik-
g; in a total sample of this size with a
% incidence of heterozygotes one might
ve expected 12 or 13 homozygous indi-
duals to occur, more if all survived to reproduce. As has been noted (Lambotte-Legrand, '55; Vandepitte, '54; Allison, '56a) in several other parts of Africa, particularly the west and central regions, in Bornu SS homozygotes are eliminated from the population before they reach adulthood, a wastage of about 1.3% of all children born.

There are no significant differences between Wakura and Hidkala in frequency of AS or AS + AC, there has been some intermarriage between the two groups despite their different languages, and these two samples of Gwoza pagans were accordingly pooled in the subsequent analysis. The 4 samples differ significantly (at 1%) in the frequency of AS, though when the

TABLE 1

People	Number examined			Phenotype						Gene frequency		
				No. observed			Frequency					
	London	Ibadan	Total	AA	AS	AC	AA	AS	AC	A	S	C
Kanouri	116	178	294	210	82	2	0.714	0.279	0.007	0.857	0.140	0.0034
Bedduwai	92	—	92	62	30	—	0.674	0.326	—	0.837	0.163	—
Shuwa	105	207	312	246	65	1	0.788	0.208	0.003	0.894	0.104	0.0016
Wakura	104	78	182	136	36	10	0.747	0.198	0.055	0.874	0.099	0.0275
Hidkala	—	129	129	106	17	6	0.822	0.132	0.047	0.911	0.066	0.0232
Total	417	592	1009	760	230	19	0.7532	0.2279	0.0188	0.877	0.114	0.0094

incidences of total abnormal hemoglobi (AS + AC) are compared the differenc are less marked (significant at 5%). Th results of comparisons of pairs of sampl are shown in table 2; again differences a more marked when the AS are contraste with the AA + AC phenotypes. The samples appear to be grouped geographicall those from the northwest of Maiduguri, th Kanouri and Bedduwai, are similar but di fer from those from the northern Cameroons, the Shuwa and Gwoza pagans, wh resemble each other. Within each of thes geographical divisions there is no signi cant difference between the earlier an later arrivals.

DISCUSSION

The finding of AC at 5% frequency i the Gwoza pagans was somewhat une pected. The C gene attains its highest fr quency in northern Ghana and adjace territories, and there is a cline of diminis ing incidence outwards in all directions, distribution pattern which has been inte preted very reasonably as representing di fusion of the gene outwards from its focu (Allison, '56; Edington and Lehmann, '5 Portier, Cabannes and Duzer, '59). Oth northern Nigerian peoples to the west the Gwoza pagans do not possess the ge at appreciable frequencies (Roberts et a in preparation), while to the southward has been suggested that the Lower Nig formed a barrier to its eastward sprea (Lehmann and Nwokolo, '59). It seem that there is a secondary focus of the ge among the hill peoples of the norther Cameroons. Whether this focus is distin or merely a salient will not be decided unt the situation in peoples of Nigeria's mi dle belt is known. The incidence of C ma or may not indicate any affinity wit peoples in the zone of high C frequencie in northern Ghana. The Gwoza folk hav no tradition of migration from the wes however, movement did occur in the opp site direction, for instance the ruling families among the Mossi reached their pre ent home in north Ghana and neighbo ing territories from the east, and the ge may possibly have been acquired and take with them. A zone of high frequency nee not necessarily represent the area of orig of a gene.

TABLE 2

Significance levels of differences between pairs of samples

	AS vs. AA + AC			AS + AC vs. AA		
	Bedduwai	Shuwa	Gwoza	Bedduwai	Shuwa	Gwoza
Kanouri	NS	5%	1%	NS	5%	NS
Bedduwai		2%	1%		5%	5%
Shuwa			NS			NS

The high frequency of AS in the Ka-
uri and Bedduwai was also rather un-
pected. As table 3 shows, frequencies of
to 25% occur in southern Nigeria, but
the north levels tend to be rather lower.
hen the idea of some association of ma-
ria with the sickle cell trait was first de-
loped (Allison, '54), high frequencies
the trait appeared to be restricted to
gions in which malaria is hyperendemic,
w frequencies in malaria-free and epi-
mic areas. Several studies (e.g., Roberts
d Lehmann, '55; Livingstone, '58) have
nce shown that in endemic zones are to
found peoples in whom the trait is
ther absent or present only at low fre-
uencies, situations explainable respec-
vely on the hypotheses that the gene has
t yet, or only recently, been introduced
the area. In Bornu the pattern is re-
rsed; the S incidence is high while ma-
ria appears to be epidemic. The present
rvey was conducted during the dry sea-
n, and parasites were observed in only
individuals in a sample of 592 (3.4%);
for comparison, among the Yoruba in a hyperendemic area where the S gene attains a comparably high incidence, the malarial parasite rate in adults is between 40 and 50% (Barber and Olinger, '31). In the samples from West Africa so far available, as in the Bornu findings, there tends to be a negative association between the frequencies of the C and S genes—higher frequencies of C are found in populations where the S gene frequency is lower (Edington and Lehmann, '56; Allison, '56b)—suggesting that the selective roles of these genes are similar.

There is no clear relationship between the frequency of the S gene and duration of settlement in Bornu of the various peoples. Unfortunately, very few figures are available for the frequencies of abnormal hemoglobin genes in the areas from which these peoples are derived. The Kanouri are unlikely to have brought the S gene with them from Tibesti, but, whether they obtained it before or after their entry into Bornu, through their long settlement in

TABLE 3

Frequencies of hemoglobins S and C in Nigerian samples

Sickling surveys	Sicklers	References
	%	
ausa, probably adult	17.5	Adamson, '51
orth Nigerians, adult	13.9	Humphreys, '52
ast Nigerians, adult	19.5	Humphreys, '52
est Nigerians, adult	19.8	Humphreys, '52
oruba, adult	21.7	Jeliffe and Humphreys, '52
ausa	15	Jeliffe, '54
ulani	18	Jeliffe, '54
erikeri	11	Jeliffe, '54

ectrophoresis surveys	No.	AA	AS	AC	SC	SS	References
		%	%	%	%	%	
alla, young children excluded	155	82	18	—	—	—	Walters and Lehmann, '56
oruba, all ages	940	68.7	23.8	6.7	1.0	0.3	Walters and Lehmann, '56
oruba, children (6 yrs.)	304	68.4	25.0	6.3	0.3	—	Garlick and Barnicot, '57
o, schoolchildren and young adults	256	74.2	25.0	0.8	—	—	Lehmann and Nwokolo, '59

their present territory they may be expected to have approached a state in which the frequency is adjusted to environmental conditions, unless of course the gene itself is of recent origin. The Bedduwai, though established only a century and a half, have already achieved a similar frequency, but they may well have partly done so in the area from which they came, territory adjoining the northeast side of Lake Chad, where sickling in Kanembu attains a frequency of some 22% (Pales et al., '55). The Shuwa, settled in Bornu for the same period as the Bedduwai, have not yet attained a similar level of the S gene though its frequency is already high. They came from an area in which it is likely that the S gene is either rare or absent, for in the Sudan the gene is only just making its appearance among the northern Nilotes and has not yet reached the Arabic-speaking peoples amongst whom there remain tribes closely related to the Shuwa. Among the Gwoza pagans there has probably been no great modification of frequencies from those established during their period of hill and foothill settlement; the S frequency of the Hidkala with their lesser use of the plains than the Wakura tends to be slightly lower than in the latter.

Considering the diversity of ethnic affinities in these peoples, the differences in their abnormal hemoglobin gene frequencies, though significant statistically in some instances, are relatively slight. The Wakura and Hidkala seem to compensate their low S levels by higher values of C so that the total abnormal hemoglobin incidence is similar to that of the Shuwa. Such differences as there are it is possible to attribute to differences in intensity of selection between the two areas covered by the investigation, but even so the similarity in frequency between the samples within each area, despite their differences in their duration of residence, requires explanation. It may be suggested that extensive interbreeding of the different peoples since they entered Bornu, either with each other or with earlier inhabitants of their present territories, has been responsible. Yet this suggestion is untenable since, although some degree of intermixture has occurred, highly significant variations are detectable in the blood group gene freque cies of these peoples, and in the easte groups there are the different contributio of S and C to be taken into account. T evidence seems to point to a relative rapid rate of change of hemoglobin ge frequency in the later arrivals; the a sence of data for the areas from which th were derived unfortunately precludes me urement of the rate. The tendency for t AS frequencies to be higher in individu under the age of about 40 than in tho of older age groups, suggested in the p liminary analysis and maintained in t total sample of Shuwa, Kanouri, and Be duwai, is still not statistically significa but would be compatible with the hypo esis of relatively recent introduction of t S gene in these peoples, and would be t more telling should the trend observed Delbrouk ('58), towards an increase AS frequency after the age of 40, pro to be of more general occurrence. Penro et al. ('56–'57) set out the conditions nec sary for three allelomorphs to be in ge etic equilibrium; from the relative viab ities observed in the present investigati it seems that the Bornu gene frequenc are not yet in a state of stable equilibriu but the Gwoza pagans appear to be som what closer to this state than the Kano or the Shuwa. The evidence is by no mea conclusive, but it seems to suggest that t rate of change of abnormal hemoglob gene frequency may have been relative rapid in Bornu.

SUMMARY

The incidence of abnormal hemoglobi has been investigated in several peopl of Bornu (Northeast Nigeria) who enter their present habitat at different perio Frequencies of hemoglobin S attain hi levels, while there appears to be a secon ary focus of C in the pagan peoples of t northern Cameroons. The evidence su gests a relatively rapid rate of change hemoglobin S frequency in this region.

ACKNOWLEDGMENTS

Acknowledgment is gratefully made financial support from the Colonial I velopment and Welfare Fund.

LITERATURE CITED

lamson, P. B. 1951 Haematological and biochemical findings in Hausa males. J. Trop. Med. Hyg., *54:* 73–77.

lison, A. C. 1954 Protection afforded by sickle cell trait against subtertian malarial infection. Brit. Med. J., *1:* 290–294.

—— 1956a The sickle cell and haemoglobin C genes in some African populations. Ann. Human Genetics, *21:* 67–89.

—— 1956b Population genetics of abnormal human haemoglobins. Acta Genetica et Statistica Medica, *6:* 430–434.

arber, M. A. and M. J. Olinger 1931 Studies of malaria in Southern Nigeria. Ann. Trop. Med., *28:* 461–508.

elbrouk, J. 1958 Contribution à la génétique de la sicklémie. Ann. Soc. Belge Méd. Trop., *38:* 103–134.

dington, G. M., and H. Lehmann 1956 The distribution of hemoglobin C in West Africa. Man, *56:* 34–36.

arlick, J. P., and N. A. Barnicot 1956–57 Blood groups and haemoglobin variants in Nigerian (Yoruba) schoolchildren. Ann. Human Genetics, *21:* 420–425.

umphreys, J. 1952 Observations on the sickle cell trait in Nigerian soldiers. J. Trop. Med. Hyg., *55:* 173–176.

eliffe, D. B., and J. Humphreys 1952 The sickle cell trait in Western Nigeria: a survey of 1,881 cases in the Yoruba. Brit. Med. J., *1:* 405–406.

eliffe, R. S. 1954 The sickle-cell trait in three Northern Nigerian Tribes. West African Med. J., *3:* 26–28.

Lambotte-Legrand, J., and C. Lambotte-Legrand 1955 Le prognostic de l'anémie drépanocytaire au Congo Belge. Ann. Soc. Belge. Méd., Trop., *35:* 53–57.

Lehmann, H., and C. Nwokolo 1959 The River Niger as a barrier in the spread eastwards of haemoglobin C: a survey of haemoglobins in the Ibo. Nature, *183:* 1587–1588.

Livingstone, F. B. 1958 The distribution of the sickle cell gene in Liberia. Am. J. Human Genetics, *10:* 33–41.

Pales, L., P. Gallais, J. Bert and R. Fourquet 1955 La sicklémie chez certaines populations Nigéro-Tchadiennes. L'Anthropologie, *58:* 472–479.

Penrose, L. S., S. M. Smith and D. A. Sprott 1956–57 On the stability of allelic systems, with special reference to haemoglobins A, S and C. Ibid., *21:* 90–93.

Portier, A., R. Cabannes and A. Duzer 1959 The frequency and distribution of abnormal haemoglobin conditions in Algeria. In: Abnormal Haemoglobins, ed. J. A. P. Jonxis and J. F. Delafresnaye, Blackwell, pp. 279–289.

Roberts, D. F., and H. Lehmann 1955 A search for abnormal haemoglobins in some southern sudanese peoples. Brit. Med. J., *1:* 519–521.

——— 1958 Preliminary observations on haemoglobin gene frequencies in the Lake Chad region. In: Symposium Geneticae Haematologicae. Acta Geneticae Medicae et Gemellologiae, 2nd supplement, 1959, pp. 75–79.

Roberts, D. F., and others, in preparation.

Vandepitte, J. M. 1954 Aspects quantitatifs et génétiques de la sicklanémie à Léopoldville. Ann. Soc. Belge. Méd. Trop., *34:* 501–516.

Walters, J. H., and H. Lehmann 1956 Distribution of the S and C haemoglobin variants in two Nigerian communities. Tr. Roy. Soc. Trop. Med. Hyg., *50:* 204–208.

igital Epiphyseal Fusion of the Hand in Adolescence: Longitudinal Study[1]

CHARLES R. NOBACK, MELVIN L. MOSS AND ELIZABETH LESZCZYNSKA

Department of Anatomy, College of Physicians and Surgeons, Columbia University, New York

Many osteological features of the fusion f bones in man have been outlined by tevenson ('24), Stewart ('34), Todd '37), Cobb ('52), Pyle and Hoerr ('55), reulich and Pyle ('50, '59) and others. hey discuss (1) the approximate mean hronological age for the fusion of various gions and bones, (2) some aspects of e sequences of bony union and (3) the se of bony fusion as a maturity indicator. general these studies are based on cross ctional data or cross sectional presen- tions derived from longitudinal material.

Because the literature is almost exclu- vely oriented to the cross sectional ap- roach, several aspects of the problem of piphyseal fusion have not previously been nswered (Noback, '54). Except for the reliminary report of Moss and Noback '58), no data are available concerning the apsed times between (1) the time a halanx ceases to elongate and the time piphyseal fusion commences, (2) the be- nning of epiphyseal fusion and its com- etion, (3) first epiphyseal fusion of the and (distal phalanx of thumb) and the mplete fusion of all digital epiphyses of e hand of any individual child.

The lack of serial radiological studies short intervals of time during the se- uences of fusion explains the absence of rior data required to determine these apsed times. This report extends and mpletes the data of our preliminary aper (Moss and Noback, '58) presenting uantitative data relating to these elapsed mes during epiphyseal fusion in the dolescent hand.

MATERIALS AND METHODS

A study population of 151 children, 11 them Negro, 57 male and 94 female as obtained from the Clinics of the Division of Orthodontics, School of Dental and Oral Surgery, Columbia University. The mean age was 13.0 years, with a range of 9–16 years.

Periodic radiological assessment of the maturational status of the entire study population was made. Those observed to be undergoing digital fusion or judged to be about to do so (fusion of the hand commenced soon after the morphological maturation of the ulnar epicondyle) were followed closely with successive exposures taken at intervals of no more than three months. During the initial phases of this study such exposures were made at lesser intervals but in no case were dosage limitations exceeded. The interval between exposures was recorded to the nearest week. The right hand was uniformly exposed, bilateral asymmetry being unimportant (Dreizen et al., '57).

A simple system of assessment of digital epiphyseal maturation was devised. Each epiphyseal region was scored in fusion units as follows: 0 units = no roentgenographic evidence of fusion; 1 unit = first evidence of fusion; 2 units = fusion almost complete, some "notching" still present; 3 units = fusion completed (see Moss and Noback, '58 for details).

For reasons of morphological and ontogenetic homology, the first metacarpal bone was considered as a phalanx for this study, and so with 15 phalanges studied, the score of a given individual could vary from 0 to 45 units.

Close approximation to the actual time required for the processes of fusion of each digital epiphysis of each child was facilitated by closely spaced serial films. The time interval between films showing either an open or a fusing epiphysis and a subsequent film showing completed fusion was noted. In the first case the interval was an overestimate since we did not know precisely the time of the onset of fusion, nor of the completion of fusion. In the second case, that of an already fusing epiphysis, there was a possibility of either an underestimate, since we did not know precisely when fusion began, or of an overestimate, since the actual time of fusion was also unknown.

---

[1] Supported, in part, by grant A-812(C), Public Health Service, National Institute of Health.

RESULTS

Epiphyseal fusion of a phalanx. Each epiphyseal fusion in a phalanx was divided into two phases (fig. 1). The first phase or prefusion phase extended from the time the phalanx ceased to grow in length until the first *radiological* sign of epiphyseal fusion. This sign was the presence of a radiopaque bridge between the epiphysis and diaphysis in the central part of the epiphyseal disc (Moss and Noback, '58). Although the prefusion stage showed no radiological signs of fusion, it was probable that histological and physiological evidence of fusion were present in the epiphyseal discs during this stage. The second phase or fusion phase extended from the first evidence of fusion until complete fusion between the diaphysis and epiphysis occurred.

Because the entire process of fusion was a continuous sequence, it was difficult to determine the exact point at which each phase began or ended unless numerous x-rays at short intervals were taken of an individual. However, from our study group several sequences of x-rays were available in a number of children which enabled us to obtain an approximation of the duration of these phases.

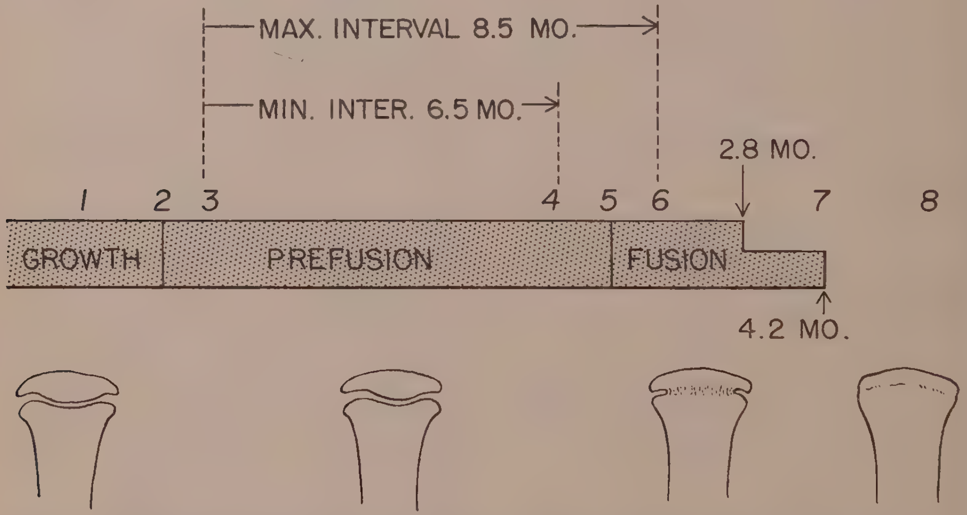


Fig. 1 The time sequence from prior to cessation of phalangeal growth until the completion of epiphyseal fusion. The numerals represent the time x-rays were taken. X-ray 1, during period of phalangeal *growth;* x-ray 2, at cessation of *growth* phase and initiation of *prefusion* phase; x-rays 3 and 4, in interval between end of phalangeal growth and commencement of epiphyseal fusion; x-ray 5, commencement of radiologically observable fusion; x-ray 6, fusing epiphysis during *fusion* phase; x-rays 7 and 8, fused digital epiphyses.

The mean maximum calculated interval (max. interval) was 8.5 ± 0.45 months. It extended from x-ray 3 to x-ray 6. The mean minimum calculated interval (min. interval) was 6.5 ± 0.69 months. It extended from x-ray 3 to x-ray 4. The exact time of these intervals could not be determined with certainty in our data.

The two lengths of the bar graphs during *fusion* phase was obtained by arbitrarily dividing the children into two groups by the criteria of rate of fusion. The mean time required for completion of a given epiphyseal union in the rapidly fusing ("fast") group was 2.8 ± 0.3 months and the slow fusing ("slow") group was 4.2 ± 0.4 months. See text for details.

The epiphyses and diaphyses of 6 phalanges—two thumb and three middle digit phalanges and the first metacarpal bone—were examined in 55 children. Ninety-nine separate serial observations (fig. 1) were made in which it was possible to determine an interval between a time after phalangeal growth had ceased (fig. 1, x-ray 3) and a time during the early stage of fusion (fig. 1, x-ray 6). The mean maximal calculated interval was 8.5 ± 0.45 months. In 48 of the 99 phalanges two successive x-rays were available within the first phase—that is when phalangeal growth had ceased and radiological fusion had not yet commenced (fig. 1, x-rays 3 and 4). The mean minimum calculated interval was 6.5 ± 0.69 months. Actually this latter figure should be longer since we could not determine with certainty the time intervals between x-rays 2 and 3 and between x-rays 4 and 5 in figure 1.

The second or fusion phase was based on 71 phalangeal observations. Calculations were made from the unimodally distributed longitudinal data which were artificially divided into two groups, children whose epiphyses fused relatively "fast" and those whose digits fused relatively "slow" (Moss and Noback, '58 for details). The mean duration of the fusion stage for a single epiphysis of the "fast" fusion group was 2.8 ± 0.3 months (N = 33) while in the "slow" group the mean interval for a single fusion was 4.2 ± 0.4 months (N = 38).

Neither the mean morphological lengths of the phalanges, nor total digital lengths, nor mean number of epiphyses fusing seemed to influence the rate of fusion. No sexual differentiation was noted.

Order of fusion. The sequence of fusion of the epiphyses of the hand varied within this study group. However, their order was arranged, in general, as noted in table 1.

This sequence was not rigid. No sex differences in the order of fusion were noted. This order did not exactly correspond with that in the atlas of Greulich and Pyle ('59).

The epiphyses of the hand seemed to fuse as groups of "fields" (table 1). These were (1) the *distal field* which included the 5 distal phalanges, (2) the *ulnar field* which included the proximal and middle phalanges of the 5th digit, (3) the *radial field* which included the first metacarpal and the proximal phalanges of thumb and second digit, (4) the *medial field* which included the middle phalanx of the second digit and the proximal phalanges of the third and 4th digits and (5) the *central field* which included the middle phalanges of the third and 4th digits.

There were both intrafield and interfield variations. For example, among 28 individual hands, fusion sequences began in

TABLE 1

The order of fusion of the epiphyses of adolescent hand

Order of fusion	Fields[1]	Number
1st digit—distal phalanx	Distal	52
5th digit—distal phalanx		52
2nd digit—distal phalanx		50
3rd digit—distal phalanx		50
4th digit—distal phalanx		50
5th digit—proximal phalanx	Ulnar	37
5th digit—middle phalanx		30
2nd digit—proximal phalanx	Radial	27
1st digit—metacarpus		26
1st digit—middle phalanx		25
3rd digit—proximal phalanx	Medial	21
2nd digit—middle phalanx		19
4th digit—proximal phalanx		19
4th digit middle phalanx	Central	12
3rd digit—middle phalanx		4

[1] See text for explanation of fields.

the ulnar field before those in the radial field in 17 hands while the reverse was true in 11 hands.

Epiphyseal fusion of the entire hand (fig. 2). The digital maturation of the hand of 55 children was measured and analyzed by a unit scoring method. The mean time for the completion of digital epiphyseal fusion of the entire hand (from fusion of distal phalanx first digit until fusion of middle phalanx third digit) was 16 months with a range of from 4 to 28 months. These results extend and refine the earlier data of Moss and Noback ('58).

If an arithmetic plot was made, with the unit scoring as the ordinate, the hand that fused in 4 months had a slope of 86°, the one that fused in 16 months a slope of 72.2° and the one that fused in 28 months had a slope of 59° (fig. 2). A significant feature was that the plot of any *individual hand* throughout its fusion sequence formed a *straight line* on this graph (see fig. 4 in Moss and Noback, '58). Once fusion commenced in a digit, its course was predictable and rapid. Thus it was possible, on the basis of two or preferably three x-rays during the time of digital fusion, to plot and predict approximately when a child's hand would be entirely fused. The rate of manual fusion was both constant and characteristic in a given child. The rates between children varied These rates were not correlated with either age or sex. Once fusion commenced in a hand it was continuous with possibly insignificant lapses undetectable by the present method.

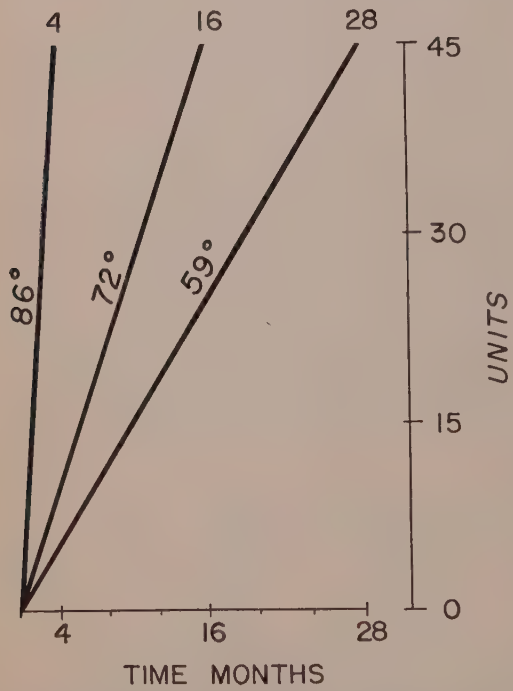


Fig. 2 Plot of the maturation of the 15 digital epiphyses of the hands of 55 adolescents as measured by unit scoring method (see Materials and Methods). Abscissa, time in months; ordinate, units as in unit scoring method. The mean elapsed time for the fusion of the 15 epiphyses of the hand is 16 months with a range of 4 months to 28 months. The mean slope for this study group was 72° with a range of 86° to 59°. In any individual adolescent, the slope is constant. Once fusion commences in a hand it is continuous with possibly insignificant lapses (see Moss and Noback, '58 for individual graphs).

DISCUSSION

The results of this longitudinal investigation confirm and extend our previous study (Moss and Noback, '58). The unusual nature of these critical data is that they cannot be derived from the myriad x-rays of the hands in existence. Only serial x-rays taken at relatively "short" intervals during epiphyseal fusion is of value in this type of study. Most x-ray collections are cross sectionally oriented. In the few excellent longitudinal studies (Greulich and Pyle, '59 as an example) the x-rays are taken at intervals that are too great especially during adolescence.

The use of skeletal maturity indicators for estimation of physiological maturity is universal. Acheson ('54) has a unit scoring method to assess skeletal maturity during the first 5 years of life. During this period the epiphyses of the hand appear The order of the appearance of these epiphyseal centers as reported by Pyle and Sontag ('42) are not correlated with the order of fusion of these epiphyses presently noted. Our paper extends Acheson's ('54) unit scoring method to the adolescent period of life, and additionally, supplements the existent valuable radiographic atlases of skeletal development.

The range of time for the fusion of all 15 digital epiphyses of the hand extends from 4 to 28 months. In all probability

ıe basic reason for differences between
ıe length of time it takes for an entire
and to fuse in different individuals is
ıat the interval between successive epi-
ıyseal fusions is short in those hands
ıat fuse quickly (4 months) and long in
ıose hands that fuse slowly (28 months).
his is likely because the length of fusion
me of each epiphysis is relatively con-
ant, 2.8 ± 0.3 months in "fast" groups
ıd 4.2 + 0.4 months in "slow" groups.
his minimizes the role of the fusion time
an epiphysis in influencing the varia-
on in the time of the overall fusion of
ıe hand.

Two critical factors must be kept in
ind in interpreting our data and conclu-
ons. (1) All our observations are based
ı radiological material. There is no infor-
ation available correlating the histology
the prefusion and fusion stages with the
ray image. It is likely that the histology
the prefusion stage is more than just
resting stage preparatory to the active
ocess of fusion. (2) Our data are in-
mplete in the sense that more x-rays at
orter intervals on more individuals are
cessary to obtain refined details. The
oblem of securing material of this nature
an adolescent population is fraught with
ımerous obstacles.

The process of epiphyseal fusion can be
rrelated with other maturational phe-
mena such as dental maturation. The
tire dentition migrates anteriorly through
e alveolar bone during the period of the
aturation of the facial skeleton (Moss,
eenberg and Noback, '59). This migra-
n occurs at the time when the digital
iphyses are open but is absent after these
iphyses have fused. Furthermore, the
nical progress of orthodontic patients is
pid and satisfactory in children with
en digital epiphyses and is slow and
ficult in children with closed epiphyses.
ıce maturational status of the hand is
good indicator of general skeletal matur-
(Greulich and Pyle, '59), seemingly,
ntal migration is correlated with it in
me manner.

CONCLUSIONS AND SUMMARY

1. The temporal sequence of epiphyseal
sion in the hands of 55 adolescents was analyzed with the use of closely spaced serial radiograms.

2. Each epiphyseal fusion was divided into two phases. The first, or prefusion, phase extended from the time a phalanx ceased to grow in length until the first radiological signs of epiphyseal fusion. Undoubtedly, histological and physiological activity relating to fusion was present but was not radiologically revealed. The second, or fusion, phase extended from the first evidence of fusion until complete fusion.

3. The mean duration of the prefusion phase, for 48 phalanges observed, was 6.5 ± 0.69 months.

4. The mean duration of the fusion phase in a "fast" fusing group was 2.8 ± 0.3 months while in a "slow" fusing group it was 4.2 ± 0.4 months. These artificial groupings were correlated with neither sex, chronological age nor length of phalanx.

5. The mean time of fusion of the entire 15 epiphyses of the hand was 16 months with a range of 4 to 28 months.

6. Once fusion commenced in an individual child, the rate was rapid and predictable if two or three radiograms were available. The rate in a child was consistent but rates varied among children. The rates were not correlated with either sex, digital length or chronological age.

LITERATURE CITED

Acheson, R. M. 1954 A method of assessing skeletal maturity from radiographs, a report from the Oxford Child Health Survey. J. Anat., *88:* 498–508.

Corb, M. 1952 Skeleton. In: Cowdry's Problem of Ageing, ed. A. Lansing. Williams and Wilkins, Baltimore, pp. 791–856.

Dreizen, S., R. M. Snodgrasse, H. Webbpeploe, G. S. Parker and T. D. Spies 1957 Bilateral symmetry of skeletal maturation in the human hand and wrist. A.M.A.J. Dis. Child., *93:* 122–127.

Greulich, W. W., and I. Pyle 1959 Radiographic Atlas of Skeletal Development of the Hand and Wrist, 2nd ed. Stanford University Press, Stanford.

Moss, M. L., S. N. Greenberg and C. R. Noback 1959 Developmental migration of mandibular buccal dentition in man. Angle Orthodontist, *29:* 169–176.

Moss, M. L., and C. R. Noback 1958 A longitudinal study of digital epiphyseal fusion in adolescence. Anat. Rec., *131:* 19–32.

Noback, C. R. 1954 The appearance of ossification centers and the fusion of bones. Am. J. Phys. Anthrop., *12:* 63–70.

Pyle, I., and N. L. Hoerr 1955 Radiographic Atlas of Skeletal Development of the Knee. C. C Thomas, Springfield.

Pyle, I., and L. W. Sontag 1943 Variability of ossification in epiphyses and short bones of the extremities. Am. J. Roentgenol., *49:* 795–798.

Stevenson, P. 1924 Age order of epiphysea union in man. Am. J. Phys. Anthrop., *7* 53–93.

Stewart, T. D. 1934 Sequences of epiphysea fusion, third molar eruption and suture closur in Eskimos and American Indians. Ibid., *19* 433–452.

Todd, T. W. 1937 Atlas of Skeletal Maturation. 1. The Hand. C. V. Mosby, St. Louis.

The Skin of Primates

I. THE SKIN OF THE SLENDER LORIS (LORIS TARDIGRADUS)[1]

WILLIAM MONTAGNA AND RICHARD A. ELLIS
Arnold Biological Laboratory, Brown University,
Providence 12, Rhode Island

In the first article of this series we described the skin of the potto (Montagna and Ellis, '59a), which is the largest member of the African lorisoids. In this paper, we deal with the smaller of the two Oriental lorisoids, the slender loris. The histological and histochemical properties and the apparently generalized features would indicate that the skin of the slender loris is even more primitive than the skin of the potto, which it resembles.

MATERIAL AND METHOD

We have used the skin of three adult males. Two of these were in excellent physical condition, but one was emaciated when we received it and had to be killed immediately. The two healthier animals ate numerous living, week-old mice, some fresh banana, and pablum mixed with milk. This regimen kept the animals in excellent physical condition, probably even better than in an optimal natural environment. Their luxurious pelage reflected their fine state of health. Pieces of skin were removed from every part of the body while the animals were anesthetized.

For general histological studies, skin was fixed in Helly's fluid and in 10% formalin and embedded in paraffin. Sections of these tissues were stained with various stains, including Giemsa, toluidin blue buffered to pH 4.5 (Montagna et al., 51), and the PAS technique for the demonstration of glycogen and other carbohydrates. Control sections were digested with fresh saliva before they were treated with PAS. Phosphorylase activity and succinic dehydrogenase activity were demonstrated in frozen sections of unfixed tissues, using respectively the methods of Takeuchi and Kuriaki ('55) and Farber and Louviere ('56). The following enzymes were studied in frozen sections of tissues fixed in chilled 10% formalin for 4 hours: (a) alkaline phosphatase (Gomori, '52); acid phosphatase (Rutenburg and Seligman, '55); nonspecific esterases (Pearse, '53); tween esterase, or lipase (Stowell and Lee, '50); acetylcholinesterase and butyrylcholinesterase (Montagna and Ellis, '57).

OBSERVATIONS

The slender loris, *Loris tardigradus*, is one of two Oriental members of the family Lorisidae; the other is the larger slow loris, *Nycticebus coucang*. Our animals were probably trapped in Ceylon, but the exact locality is not known. Judging from their size, 7 to 8 inches in length, and the general coloring of the pelage, ash-gray above, frosted with white, and largely white with a suffusion of yellow on the ventral parts (for fuller description see Hill, '53), these animals seemed to be *Loris tardigradus nordicus*. The naked skin of the lips, the sides of the nose, the eyelids, and the margin of the soles, was yellowish. The large eyes were surrounded by a rim of blackish hairs which gave the animals a goggled appearance. The pure white hairs of the gular region continued dorsally and laterally with the long white hairs of the cheeks (figs. 1–4).

Slender lorises are small, slow-moving, nocturnal animals with long, slender limbs (figs. 1–4). During the day, they

---

[1] This work was supported by grants from the United States Public Health Service, RG-2125 (C9), The National Science Foundation, G-4392, and Colgate-Palmolive Company.

sleep while hanging to the sides of the cage, with the head resting against their bellies, between the thighs. When disturbed, they voice a bird-like chatter and soft, short growling noises.

The animals have a moderately strong, somewhat unpleasant odor emanating from the skin. The odor lingers on one's hands after the animals have been handled (Hill, '56 makes a similar observation). The pelage of lorises is relatively short and dense on the dorsal and extensor surfaces, and scantier and longer on the ventral and flexor surfaces. When the fur is clipped off, the skin is either pinkish or yellowish. Yellow pigment is conspicuous on the dorsal side of the manus and pes, on the extensor surfaces of the forearm and leg, on the ears, and on the naked skin near the margin of the eyelids, lips and nose. The pigment is probably a carotinoid, but we did not investigate it. The skin of the scrotum has a marbling of brown pigmentation, but that elsewhere has no pigment showing through.

After the anesthetized animals are clipped, the flexor surface of the arm becomes covered with a watery fluid which has the characteristic, strong odor of the animal. Scattered beads of similar fluid are also found over the extensor sides of the forearm and legs. The skin where fluid is secreted freely has a yellowish color; the base of the hairs in these areas has a yellow incrustation.

Hill ('53) gives an excellent account of the anatomy, the classification and the general biology of the lorises, and Brandt ('40) discusses the details of the hair tracts in two fetuses. There is a brief report by Hill ('56) on the glands of the arm, and by Klaar ('24) on the skin of the axilla. These are the only studies we know on the skin of these animals. Although similar in some respects to the skin of the potto (Montagna and Ellis, '59), the skin of the slender loris has many interesting peculiarities.

The skin is very thin; it is much thicker on the dorsal and extensor surfaces than it is on the ventral and flexor surfaces. It is thickest on the nape, and thinnest on the gular and axillary regions and on the medial side of the thighs.

The epidermis

The epidermis has no undersculpturing and rests flat on the dermis. The epidermis over most of the body is surprisingly thin with a malpighian layer usually composed of two or three layers; that over the scrotum is much thicker. A discontinuous, barely detectable granular layer is composed of flattened cells that contain some recognizable keratohyalin granules and some non-stainable, refringent granules. The stratum corneum is about 10 layers of cells thick and varies little from one place to another.

The underside of the very thick epidermis of the volar side of the hands and feet has deep ridges. At the bottom of the ridges are attached the narrow ducts of the sweat glands; the path of these ducts through the epidermal ridges is either straight or slightly twisted. All mitotic activity is restricted to the cells at the bottom of the ridges, there being none in the valleys between them. The malpighian layer is thick and the granular layer is three or 4 cells in thickness; these cells, like those of the general body epidermis, have relatively few basophil-staining keratohyalin granules and numerous achromic and refringent granules. The corneal layer is very thick, but the stratum lucidum is poorly defined.

The epidermis is almost free of melanin and dendritic melanocytes. Recognizable melanocytes are found predictably only in the epidermis of the scrotum and occasionally in that of the ears and the perianal regions. Even the epidermis of the palms and soles has none.

Only the basal layer of the general skin epidermis stains moderately well with basic dyes. In the thick epidermis over the scrotum, the lower three or more layers of the malpighian layer are deeply basophil. In the palms and soles the entire malpighian layer stains fairly intensely with basic dyes.

Except near the depressions around the pilary canals, the epidermis is free of glycogen. Over the scrotum, where it is thicker, moderate amounts of glycogen may be found in the cells in the middle of the malpighian layer. In the palms and soles, the cells in the upper malpighian layer often contain glycogen.

All viable epidermal cells everywhere ontain succinic dehydrogenase activity; he largest concentration of the enzyme is n the basal layer. The epidermis everyvhere has strong phosphorylase activity; he reaction is always more intense on the entral and flexor surfaces than on the orsal and extensor surfaces.

The entire epidermis up to, and includng the granular layer, is strongly reactive or nonspecific esterases (figs. 5, 17, 24), he corneal layer being unreactive. In the alms and soles esterase activity is conentrated in the entire malpighian layer nd particularly in a band that correponds to the combined upper granular ayer and stratum lucidum; the corneal ayer shows a moderate reaction (fig. 24). he distribution of tween esterase and acid hosphatase corresponds to that of nonpecific esterases. There is no alkaline hosphatase in the epidermis.

The pilary system

Hair follicles grow in clusters or islands f 4 to 20 or more (fig. 5), but the pilary anal of each follicle opens separately to he surface (fig. 6). Small sebaceous lands are attached to the outer root heath a short distance below the surface fig. 5). The larger follicles have a recogizable "hair bulge" to which are attached he arrector muscles; the small follicles ave no muscles. Growth of hair is mosaic; rowing follicles may be found anywhere n the body, and hair groups may contain oth growing and quiescent follicles. There s a great disparity in the size of the folcles in each hair group, and the size of he hairs they produce may range from 10 o several hundred microns. Thus, one nds tiny, non-pigmented hairlets without medulla, small hairs with a continuous r discontinuous pigmented medulla, and arge hairs with a medulla like that of odents, arranged in blocks separated by ir spaces (fig. 7).

Growing follicles, regardless of their total iameter, are very long and slender and sually extended below the base of the ermis into the subdermal fat (fig. 7). Vhere the skin is very thin, the lower part f active hair follicles grows parallel to he surface of the skin, flattened against he panniculus carnosus. On the ventral portion of the body and on the skin of the ears (fig. 11), even quiescent follicles are bent.

Growing follicles have an outer root sheath one or two cells thick, and an inner root sheath with the three layers each one cell thick. At the bottom of the pilary canal, before it disappears, the inner sheath becomes thicker and corrugated as in the follicles of sheep (Auber, '52). The bulb of growing follicles is narrow and long (fig. 8). Follicles which produce pigmented hairs have a few dendritic melanocytes in the upper third of the bulb, the lower two-thirds being unpigmented. The dermal papilla is narrow and long (fig. 8); its apex is acuminate and continues for a distance up the follicle, below where the medulla is organized. The dermal papilla is avascular even in the larger follicles; very few blood vessels surround the lower part of the follicle.

Quiescent hair follicles are short, and their bases rest about midway in the dermis (figs. 5, 6); the long, narrow hair club is surrounded by a thin epithelial sac one or two cells thick (fig. 9). The cells of the epithelial sacs are round and form a pebbly outer wall. The "hair germ" is a short, conical peg of undifferentiated cells scattered between which are a few dendritic melanocytes. The cells of the epidermal capsule often contain pigment granules. This is odd since the follicles are not heavily pigmented. Regardless of the amount of pigment in the hair shafts above the surface of the skin, the club of these hairs and the shaft within the follicle above the club are unpigmented and nonmedullated (fig. 9). Melanocytes in active hair follicles are discretely located only in the upper third of the bulb. Mitotic activity is abundant in the lower two-thirds of the bulb (fig. 8). The extensive unpigmented part of the bulb is the matrix proper. The size of the matrix seems to be related to the rate of growth of the hair produced. When club hairs are plucked from quiescent follicles, the rate of regrowth of the hair is a little more than one millimeter per day. This growth rate is similar to that of the hair of the potto, and that of rodents (Mohn, '58), but it is nearly three times the rate of growth of human hair (Myers and Hamilton, '51).

The basophil staining properties of the hair follicles are similar to those of other mammals (see Montagna, '56). The dermal papilla of active follicles stains metachromatically with toluidin blue, whereas the papilla of quiescent follicles does not. As in all other mammals, the outer root sheath of active follicles contains abundant glycogen, particularly concentrated around the long keratogenous zone. Quiescent follicles also contain glycogen in the cells of the epithelial sac (fig. 9).

Active follicles abound in succinic dehydrogenase activity; enzyme activity is most intense in the bulb and in the cells of the outer root sheath around the keratogenous zone of active follicles. The epithelial sac and the hair germ of quiescent follicles have moderate enzyme activity.

The epithelium of the pilary canal and the outer root sheath have strongly reactive phosphorylase activity (fig. 10). None of the other cells in the follicles shows a reaction. The entire epithelial capsule around the club of quiescent hair follicles has an intense phosphorylase reaction (fig. 11).

The dermal papilla of either active or quiescent follicles is reactive for alkaline phosphatase; no other part of the follicles shows a reaction. There are no phosphatase-rich blood vessels around the lower part of the follicles. Both active and quiescent follicles have a generalized reaction for acid phosphatase. Esterases are heavily concentrated in the outer sheath of active follicles and at the bottom of the pilary canal, where the corrugated inner sheath disappears. Quiescent follicles have a generalized but strong esterase reaction (fig. 5).

The sebaceous glands

The sebaceous glands are very small. They have no specialized duct which opens into the pilary canal and practically no lumen in the center of the fundus. In the scalp and the scrotum the glands are larger than elsewhere and have a short duct. At the periphery of the acini are a few flat, undifferentiated cells, which seldom show mitotic activity. The sebaceous glands, then, are poorly developed and not highly functional.

The glands have no peculiarities. Th
flat, peripheral undifferentiated cells an
the cells of the duct, when this is present
stain an intense basophil color with tolu
idin blue. The differentiated cells hav
variable numbers of basophil granules be
tween the fine lipid droplets. None of th
glands contains glycogen; even the duct
have no trace of it.

The glands have some succinic dehy
drogenase in the undifferentiated cells a
the periphery and in the duct; they hav
no phosphorylase activity (fig. 11). Th
only reaction for alkaline phosphatase i
localized in the form of sparse, coars
granules in the mature sebaceous cells i
the center of the glands. There is a di
fuse, but moderately strong, acid phos
phatase reaction throughout the glan
The glands are intensely reactive for non
specific esterases (figs. 5, 7, 17), but hav
practically no tween esterases.

The only large sebaceous glands are th
meibomian glands in the eyelids. Thes
glands, like those in the eyelids of mos
other mammals, are surrounded by man
fine nerves which contain specific cholin
esterase (Montagna and Ellis, '59b).

The sweat glands

One, or occasionally two, sweat gland
grow together with each hair group (figs.
6, 10). The glands are smallest and leas
numerous on the scalp, the face, and th
ventral regions, where the hair groups ar
largest. The glands are large and nume
ous on the medial sides of the forearm an
thigh; they are disproportionately large o
the medial side of the arm. In the ski
covering the pinna of the ear, near
every hair follicle is associated with
tiny sweat gland (fig. 11).

A dilated, variably coiled secreto
tubule extends through the dermis and
the subcutaneous fat. The coiled segme
opens to the surface by a very narrow
straight duct (fig. 11). Although th
glands grow alongside one of the hair fo
licles, the ducts open separately to th
surface near the pilary canal in a funne
like dilatation.

The variability of the height of the ep
thelium of the glands, the degrees of dil
tation, and the differences in the conte
of the lumina, suggest that the glands a

in different states of functional activity. This activity is not related to the functional state of the hair follicles near them.

The ducts have an approximate diameter of 20 μ, and are composed of two layers of very low cuboidal cells flatter in the inner than in the outer layer. The wall of the duct is several layers thick at its junction with the epidermis. The transition between the simple columnar or cuboidal epithelium of the secretory segment and the thin, two-layered duct is sudden (figs. 10, 11). The secretory epithelium may be cuboidal or tall columnar, with the apices of the cells protruding into the lumen.

In the duct, the basal cells stain intensely with toluidin blue; the luminal cells, which are partially hyalinized stain weakly. In the tall columnar secretory cells, basophil granules are clustered at the base of the cells and around the nucleus, but the luminal cytoplasm is free of such granules. In the cuboidal cells the granules may extend practically to the free surface. The cuboidal cells have one spherical nucleus; the tall cells often have two spherical or oval nuclei. The content of the glands is rarely basophil, but that in the orifices of the ducts is intensely so.

The cells of the duct, and particularly those at its junction with the secretory part, contain glycogen; the terminal part of the duct near the orifice is free of it. Dust-like granules of glycogen may also be found in some of the tall secretory cells. These cells contain variable amounts of PAS-positive granules, particularly in the glands of the scrotum (fig. 12), those in the eyelids (glands of Moll), and those in the palms and soles at the transition of glabrous and hairy skin. Elsewhere on the body the glands may or may not have such granules. Regardless of the presence or absence of PAS-positive granules, the fluid within the coiled part of the glands is not PAS-positive, but that in the ducts near their orifices is strongly PAS-reactive. The glands of Moll in the upper eyelids contain PAS-positive pigment granules, but none of the other glands contain recognizable pigment.

The cells of the ducts contain practically no succinic dehydrogenase activity, but the secretory cells are full of coarse, reactive granules. The myoepithelial cells have practically no reaction. The duct has a moderate to strong phosphorylase activity. In contrast with the findings in other primates, the cells of the secretory cells also have a moderate to strong phosphorylase reaction; the myoepithelial cells have the most intense concentration of the enzyme (figs. 10, 11). The ducts have a very weak alkaline phosphatase reaction, the secretory cells have a strong reaction only in the apical part toward the lumen (fig. 13). The glands have a moderate reaction for acid phosphatase, and a very strong reaction for esterases (fig. 5).

The brachial organ

The skin on the medial side of the arm is so rich in large tubular coiled glands that the difference from the other skin is palpable. In shaved, live animals this region becomes covered with a watery, yellowish fluid with an unpleasant smell. This specialized glandular region, which was discovered and described briefly by Hill ('56), is the *brachial organ.*

The short, narrow ducts of the glands of the brachial organ open to the surface independent of hair follicles (figs. 16, 17). The total diameter of the duct is less than the height of the secretory cells. The general structure of the glands is similar to that of the apocrine glands elsewhere on the body. The secretory cells, however, are very tall, and the myoepithelial cells are larger (figs. 14, 15).

The duct contains some glycogen only in the basal cells. The spectacularly tall secretory cells (fig. 14) may contain coarse glycogen granules above the nucleus, together with faintly PAS-positive saliva digestible granules and plaques. The large secretion droplets inside of, or attached to the apex of the cells are never PAS-positive (figs. 14, 15). The secretion within the lumen of some tubules is strongly PAS-positive and saliva resistant with clear, unreactive globules scattered through it (figs. 15); in other tubules the secretion consists entirely of PAS-negative globules. The luminal cytoplasm of the secreting cells is full of secretion fluid, which seems to ooze out of the cell into the lumen. The secretion material in the ducts near the excretory orifice and that encrusted on the surface of the skin is PAS-positive.

Some basophil granules are clustered at the base of the secretory cells below the nucleus. The upper half of the very tall cells is either achromic or it stains very lightly with toluidin blue. The cytoplasm that bulges into the lumen and the intra- and extracellular droplets are always achromic. In some glands the secretion within the lumen may be composed entirely of achromic or slightly basophil globules; in other glands it may be homogeneous and intensely basophil. In some glands the homogeneous, basophil colloid may contain achromic globules scattered through it. Regardless of the appearance and staining property of the secretion, the luminal border of the secretory cells is always covered with a barrier of achromic globules which look like soap bubbles being released from the cells. The content of the duct and the incrustations on the outer surface of the skin are always intensely basophil. This corresponds completely to the PAS reactivity of the secretion. The secretion of these glands, then, is first achromic and PAS-negative, but on standing it attains both basophilia and PAS reactivity.

The duct has a low reactivity for succinic dehydrogenase, but the secretory cells are replete with reactive granules; those at the base of the cells are aligned along the axis like basal rodlets or striations. Even the cytoplasmic blebs that protrude into the lumen have a strong succinic dehydrogenase reaction. The myoepithelial cells are practically non-reactive. The glands are rich in phosphorylases (figs. 16) and esterases (fig. 17). They differ from the other glands in having a reaction for alkaline phosphatase so strong that after incubation for a few minutes in the substrate the color produced is so deep that all details become masked (fig. 18). With this exception, the histochemical attributes of the glands of the brachial organ are similar to those of the other apocrine glands. There is, however, one profound difference between these and the other apocrine glands: the glands of the brachial organ are surrounded by nerves rich in cholinesterases which attack both acetylthiocholine and butyrylthiocholine substrates. The reaction in the nerves is stronger with butyrylthiocholine and the enzyme must be mostly nonspecific cholinesterase.

The glands of the palms and soles

These sweat glands are embedded in the thick subcutaneous fat, and their straight, narrow ducts open at spaced intervals along the crests of the epidermal ridges (fig. 24). The path of the duct inside the epidermis is straight or slightly coiled. The duct joins the thick secretory coil abruptly and the gross appearance of the gland is that of an apocrine gland. The wall of the ducts has two layers of flat cuboidal cells, the luminal ones being flatter than the basal ones. The duct is thicker where it joins the secretory coil, proximally, and the epidermal ridges, distally. The secretory tubules are lined with cuboidal or pyramidal cells (fig. 19). A thick layer of myoepithelial cells separates the glandular cells from the thick basement membrane.

The secretory cells are all alike and different from either the dark or the clear cells of the glands of the higher primates. The cells are pyramidal with the nucleus pressed against the base, like that of mucous cells. The cytoplasm is full of colorless globules between which can be seen small, basophil granules (fig. 19). The globules stain a faint metachromatic color with toluidin blue.

Most of the cells of these glands contain neither glycogen nor other PAS-reactive material (figs. 20, 21). The cells of the duct at the junction with the secretory cells have some small PAS-positive granules, which are of no consequence. In spite of this, the glands often contain moderately PAS-positive, saliva resistant granules, and the duct always contains a strongly positive colloid. These particular features are like those of the glands of the brachial organ.

The sweat glands of the palm and sole are no more strongly reactive for succinic dehydrogenase activity than the glands elsewhere on the body. The cells of the duct are weakly reactive, and the secretory cells have a moderately strong reaction.

he myoepithelial cells are nearly unre- ctive. The entire gland shows a moderate eaction for phophorylase activity; the yoepithelial cells are intensely reactive figs. 22, 23).

The glands have scant reactivity for lkaline phosphatase, and moderate reac- vity for acid phosphatase. The secretory oil is also moderately reactive for non- pecific esterases, and the ducts are weakly eactive (fig. 24).

The secretory coils are surrounded by erves which contain both acetylthiocholin- sterase (figs. 25, 26) and butyrylcholin- sterase, the latter showing the strongest eaction. This means that the nerves ontain both specific and nonspecific sterases.

The dermal papillae between the epi- ermal ridges of the palms and soles con- ain numerous, round Meissner corpuscles fig. 25), which contain both cholin- sterases. Cholinesterase-rich nerves form etworks around the bases of the epi- ermal ridges and around the junction of e sweat gland ducts with the epidermis. acinian corpuscles are very large in the alms and soles (fig. '27); the core of ese corpuscles is reactive for both cholin- sterases, as is that of man and other ammals (Beckett et al., '56; Loewenstein nd Molins, '58).

The dermis

The dermis is relatively thick and con- sts almost entirely of a fibrous reticular yer. A very thin papillary layer com- osed of delicate collagenous fibers and a w fibroblasts separates the epidermis om the reticular layer. Blood vessels are ldom seen rising to the surface. The ndothelium of the few cutaneous vessels seldom reactive for alkaline phosphatase. he dermis of the palms and soles, how- ver, has a good papillary layer and moder- ely numerous capillary loops whose endo- elium is strongly alkaline phosphatase ositive. The cutaneous appendages are most in contact with the reticular layer, nd what vessels surround them do not ave an endothelium reactive for alkaline osphatase. A few elastic fibers are und mostly between the collagenous fi- rs in the deeper parts of the dermis.

The small arteries and arterioles which traverse the dermis, particularly in the vicinity of the cutaneous appendages, are surrounded with a very scanty bed of areolar tissue. The dermis in the brachial organ and in the scrotum, however, is more richly vascularized than that elsewhere. The large, smooth muscle fibers of these vessels, which are largely oriented transversely, contain glycogen, and they are rich in phosphorylase activity. The large nerve trunks have strong phosphorylase reaction in the myelin sheath. In the scrotum, numerous nerve fibers, rich in acetylcholinesterase, are found near the surface of the dermis. Small, oval tactile end-organs in the skin of the scrotum contain both specific and nonspecific cholinesterases.

The dermis has a remarkably scanty cell population. Some dermal dendritic melanocytes are found consistently only in the scrotum. Mast cells are few, except in the perivascular beds of the brachial organ, lips, scrotum and the palms and soles. Mast granules are well preserved by the fixatives used; they have varying degrees of metachromatic stainability and are strongly PAS-positive.

The slender loris has an extensive dermal musculature (Hill, '53); with very few exceptions, such as the gular region, the medial and distal surfaces of the appendages, etc., the skin has a good panniculus carnosus. The scrotum has a very thick tunica dartos, discontinuous and broken up by blood vessels, glands and hair folicles.

DISCUSSION

The many generalized features of the skin of the slender loris suggest that it is very primitive. Although the hair tracts depart considerably from the simple basic pattern found on the body of *Ornithorhynchus* (Brandt, '40), they have remained fairly simple. The hair is fine and woolly and distributed in large, poorly defined hair groups like those of the potto (Montagna and Ellis, '59). Klaar ('24) records 5 to 9 hairs per group, but the disparity is much greater than he indicates, there being 4 to 20 anywhere on the body. Hair follicles are long and narrow, poorly vascularized, and resemble those of rodents. The hair groupings, and the follicles, then, are fairly primitive. Two distinctive features of the hair follicles, however, at once place them among those of primates. Quiescent follicles contain glycogen and all follicles, active or quiescent, are rich in phosphorylase.

Since the groups of hair follicles are characterized by the presence of one apocrine sweat gland, the development of the glands seems to be related to the aggregation of the follicles into groups. Groups containing large numbers of follicles frequently have two apocrine glands. Thus, there seems to be a direct relation betwen the number of hair follicles and the number of glands per group.

The developmental history of these glands is not known. Like those of other lorisoids, they open separately to the surface of the skin and not into a pilary canal. This is in contrast with the apocrine glands of man and of some of the higher primates, which usually open into the pilary canal. Not knowing what the skin of the fetus is like, it is not possible to be sure if these glands develop from the surface epidermis, or as appendages of hair follicles.

The glands in the skin of the loris are morphological models of apocrine glands. Even some of their histochemical characteristics, such as the lack of glycogen, and intense concentrations of esterases, are concordant with the attributes of apocrine sweat glands. However, the apocrine glands of the loris abound in phosphorylase activity, and this makes them different from the apocrine glands of all other animals we have studied, including those of the potto (Montagna and Ellis, '59), which are free of this enzyme. These glands, then, embody some of the properties of both eccrine and apocrine glands. The glands of the brachial organ depart even more strikingly from the specialized features of the apocrine glands of man, in being altogether free from hair follicles, in containing phosphorylase, and in being surrounded with nerves that contain cholinesterases.

Nearly all primates studied have somewhere on their bodies specialized skin areas in which are concentrated large apocrine glands. The brachial organ of the slender loris represents such a specialized glandular field. Similarly specialized glandular skin is found over the genital areas of the potto (Montagna and Ellis '59), and the lemurs have certain arm glands on the flexor side of the arm (Sutton, 1887). Similar specialized glandular areas are also found in the skin at the ventral base of the tail of platyrrhini (Hil et al., '59). Even in man, the axillary organ is comparable to these specialized glandular areas of skin. The glands in these areas all secrete variably fetid substances and are well developed in both sexes. This appears to be one of the peculiarities of the skin of primates.

The glands of the palms and soles are also peculiar. Their gross morphology is like that of apocrine glands. They are singularly different from the eccrine gland of man and of other mammals. The have no recognizable clear and dark cell such as are found in the glands of man and other primates. The cells have numerous, nearly achromic secretion granules unlike those found in the eccrine gland of other animals. Their most unusual feature is that they have no glycogen in the secretory cells, even though they have abundant phosphorylase activity and are innervated by nerves rich in cholinesterase These glands have a striking resemblance to the glands with "reticulated cytoplasm found in an occasional, apparently normal human being (Holyoke and Lobitz, '52) The eccrine sweat glands of the slow lori are strange. They have little resemblance to most eccrine glands we have seen, and we do not know enough comparative anatomy to be able to tell what phylogeneti significance they have.

SUMMARY

1. The epidermis, except for that ove the scrotum and on the palms and soles is very thin. Dendritic melanocytes ar found predictably only in the epidermi of the scrotum; elsewhere it is free o melanin. The epidermis contains a number of enzymes, including phosphorylase

2. The very long and narrow hair fo licles grow in groups of 4 to 20. Hai follicles, active or quiescent, contain glycogen and phosphorylase activity. The cell of the epithelial capsule of quiescent fo

cles contain melanin granules, even
ough active follicles have very little pig-
ent.

3. The sebaceous glands are very small
nd relatively inactive; they contain abun-
ant esterases but have neither glycogen
or phosphorylase.

4. Apocrine sweat glands are distrib-
ted one or two to each hair group. These
ands have all of the attributes of apo-
ine glands. However, they have a rich
ntent of phosphorylase activity in strik-
g contrast with the apocrine glands in
her mammals we have studied.

5. In the skin on the medial side of
e arm are concentrated numerous, large
ocrine glands which constitute the bra-
ial organ. The glands of the brachial
gan differ from those elsewhere on the
dy in being very rich in alkaline phos-
atase and in being surrounded by nerves
hich contain cholinesterases.

6. The general shape of the eccrine
ands on the palms and soles is like that
apocrine glands. The secretory cells
e peculiar in being all of one type, in
aving a cytoplasm replete with achromic
anules, and in being free of glycogen.

7. These details and others listed sug-
st that the skin of the slender loris is
ry primitive.

LITERATURE CITED

uber, L. 1952 The anatomy of follicles producing wool-fibers, with special reference to keratinization. Trans. Roy. Soc. (Edinburgh). 62: 191–254.

eckett, E. B., G. H. Bourne and W. Montagna 1956 Histology and cytochemistry of human skin. The distribution of cholinesterase in the finger of the embryo and the adult. J. Physiol., *134:* 202–206.

randt, W. 1940 The prenatal development of the hair tracts in primates. Human Biol., *12:* 203–231.

arber, E., and C. D. Louviere 1956 Histochemical localization of specific oxidative enzymes. IV. Soluble oxidation-reduction dyes as aids in the histochemical localization of oxidative enzymes with tetrazolium salts. J. Histochem. Cytochem., *4:* 347–356.

Gomori, G. 1952 Microscopic Histochemistry. Principles and Practice. The University of Chicago Press, Chicago, Illinois.

Hill, W. C. O. 1953 Primates. Comparative Anatomy and Taxonomy. I. Strepsirhini, pp. 175–194.

Hill, W. C. O. 1956 Body odour in lorises. Proc. Zool. Soc. London, *127:* 580.

Hill, W. C. O., H. M. Appleyard and L. Auber 1959 The specialized area of skin glands in "*Aotes*" Humboldt (Simiae Platyrrhini). Trans. Roy. Soc. Edinburgh. *63:* 535–551.

Holyoke, J. B., and W. C. Lobitz, Jr. 1952 Histologic variations in the structure of human eccrine sweat glands. J. Invest. Dermatol., *18:* 147–166.

Klaar, J. 1924 Über die axillaren Knäueldrüsen der Affen. Zeitschr. Anat. EntwGesch., *72:* 609–627.

Loewenstein, W. R., and D. Molins 1958 Cholinesterase in a receptor. Science, *128:* 1284.

Mohn, M. P. 1958 The effects of different hormonal states on the growth of hair in rats. In: Biology of Hair Growth, Eds. W. Montagna and R. A. Ellis. Academic Press, Inc., New York.

Montagna. W. 1956 The Structure and Function of Skin. Academic Press, Inc., New York, New York.

Montagna, W., H. B. Chase and H. P. Melaragno 1951 Histology and cytochemistry of human skin. I. Metachromasia in the mons pubis. J. Nat. Cancer Inst., *12:* 591–597.

Montagna, W., and R. A. Ellis 1957 Histology and cytochemistry of human skin. XII. Cholinesterases in the hair follicles of the scalp. J. Invest. Dermatol., *29:* 151–157.

——— 1959a The skin of primates. I. The skin of the potto (*Perodicticus potto*). Am. J. Phys. Anthrop., *17:* 137–162.

——— 1959b Cholinergic innervation of the meibomian glands. Anat. Rec., *135:* 121–128.

Myers, R. J., and J. B. Hamilton 1951 Regeneration and rate of growth of hairs in man. Ann. N. Y. Acad. Sci., *53:* 562–568.

Pearse, A. G. E. 1953 Histochemistry, Theoretical and Applied. Little, Brown and Co., Boston, 530 pp.

Rutenburg, A. M., and A. M. Seligman 1955 The histochemical demonstration of acid phosphatase by a post incubation coupling technique. J. Histochem. Cytochem., *3:* 455–470.

Stowell, R. E., and C. S. Lee 1950 Histochemical studies of the mouse liver after single feeding of carbon tetrachloride. Arch. Pathol., *50:* 519–537.

Sutton, J. B. 1887 On the arm-glands of the lemurs. Proc. Zool. Soc. London, pp. 369–372.

Takeuchi, T., and H. Kuriaki 1955 Histochemical detection of phosphorylase in animal tissues. J. Histochem. Cytochem., *3:* 153–160.

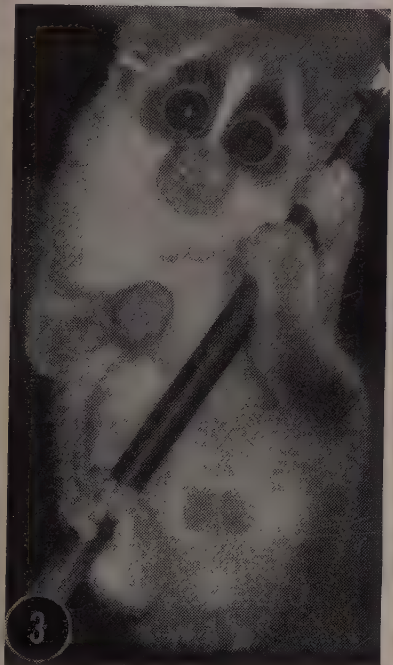
PLATE 1

EXPLANATION OF FIGURES

1, 2, 3, and 4. Different attitudes of a healthy male slender loris posed in the laboratory.

①

②


③

④

PLATE 2

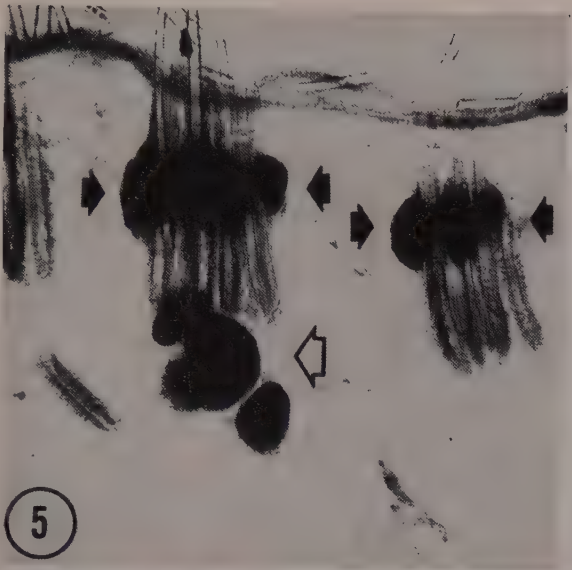
EXPLANATION OF FIGURES

5 Frozen section of the skin of the back, demonstrating non-specific esterases. This section shows the arrangement of hair groups; the skin between each hair group is free of hair follicles. All of these follicles are quiescent. The small sebaceous glands appear as humps on the side of the follicles very near the surface (arrows). Only one of the hair groups shows an apocrine sweat gland (light arrow); this is strongly reactive for nonspecific esterases. Approximately × 50.

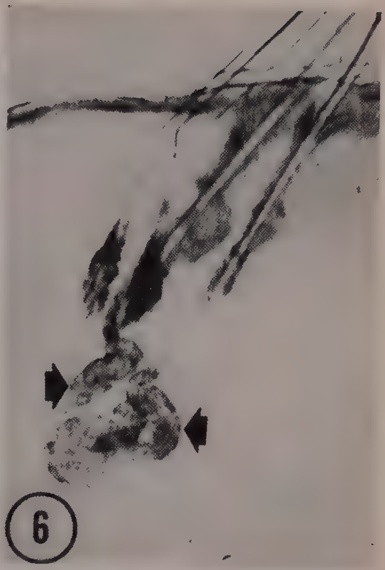
6 Very thin frozen section from the lateral side of the forearm, lightly treated to show phosphorylase activity, showing a hair group associated with two apocrine glands (arrows). Note that each hair follicle opens individually to the surface. Approximately × 50.

7 Frozen section of skin from the back treated for nonspecific esterases. One of the longer hair follicles is present in its entirety. The hair shaft is heavily medullated and the medulla is arranged in cells which contain air spaces. Approximately × 50.

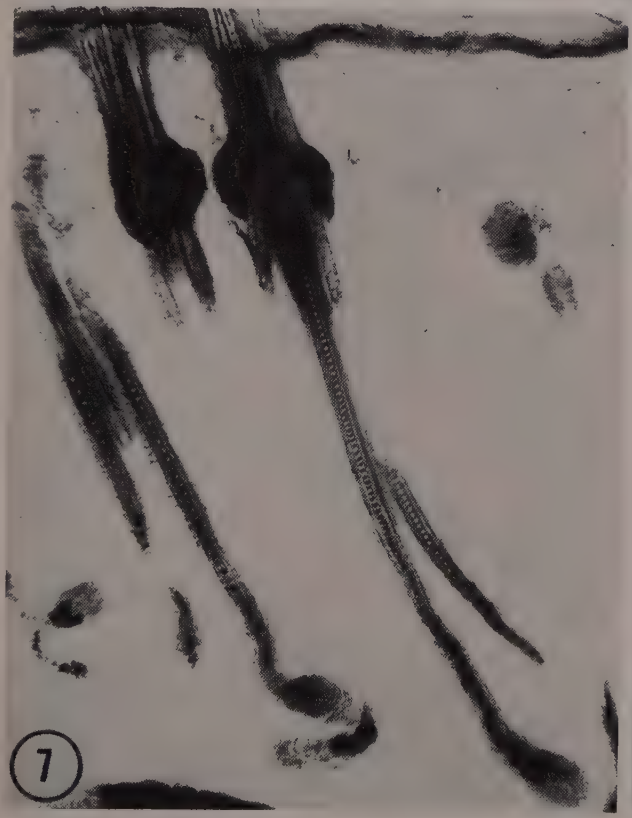
8 The elongated bulb from an active hair follicle. The narrow, long dermal papilla is clearly seen; its apex is not in the plane of the section. This is from the skin of the axilla, in which most of the hairs are colorless, and, therefore, there are no dendritic melanocytes in the upper third of the bulb. Approximately × 200.



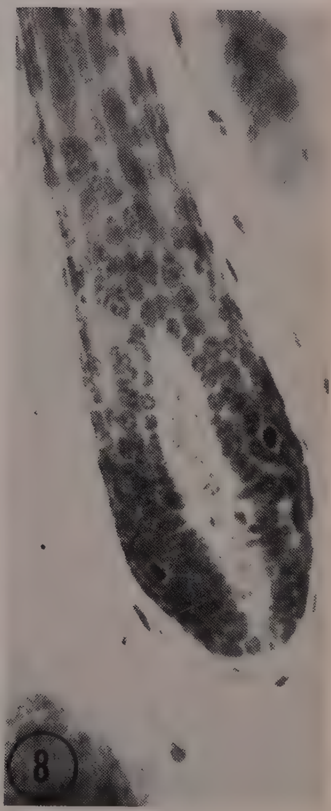
5



6



7



8

PLATE 3

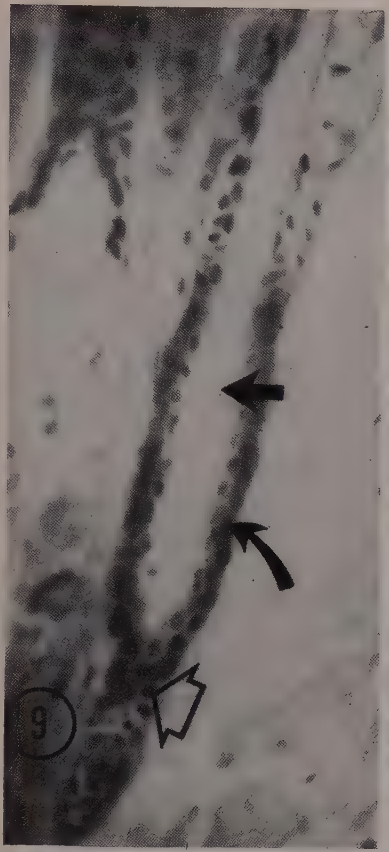
EXPLANATION OF FIGURES

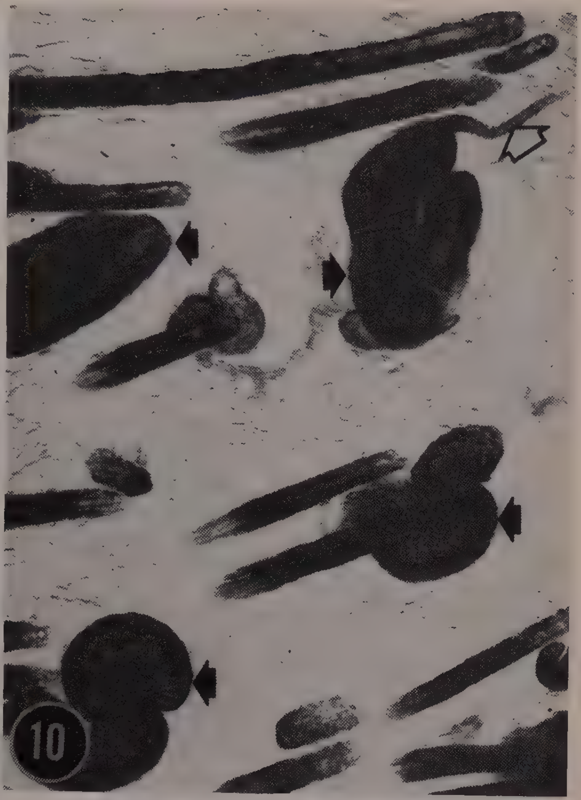
9 Quiescent hair follicles from the back. The straight arrow points to the non-pigmented club and hair shaft. The curved arrow points to the epithelial capsule which contains glycogen. The white arrow points to the hair germ below which may be seen the dermal papilla. Section treated with the PAS reaction. Approximately × 150.

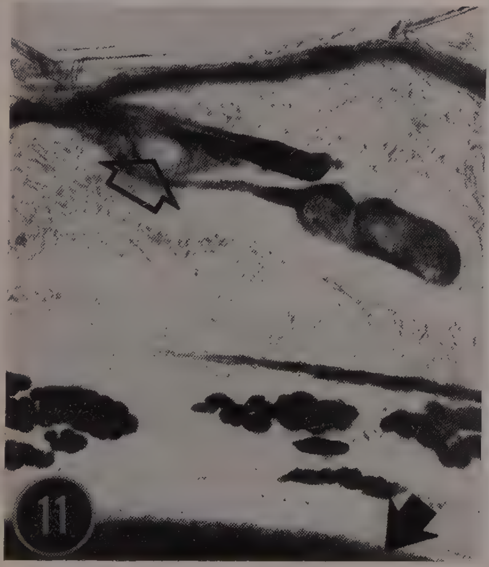
10 Relatively superficial frozen section of the lateral surface of the arm showing parts of few hair groups associated with one sweat gland (black arrows). The very narrow duct (white arrow) may be seen in one of the glands. This section was treated to show phosphorylase activity. The outer root sheath of the active hair follicles, as well as the duct and secretory portion of the apocrine sweat glands, are strongly reactive for phosphorylase. Approximately × 65.

11 Strong phosphorylase activity in the skin from the ear. The surface epidermis, the epithelial capsule of the quiescent follicle, and the apocrine sweat gland are all reactive. The skeletal muscle deep in the section as well as the chondrocyte (black arrow) are strongly reactive. The white arrow points to the sebaceous glands which are non-reactive for phosphorylase activity. Approximately × 50.

12 Section through the secretory portion of apocrine glands in the scrotum, treated with PAS. The tall columnar cells bulge into the lumen. The gland contains a moderately PAS-positive flocculent secretion. The small glycogen granules, as well as the PAS-positive, saliva resistant granules found in apical portions of the cells, are not well shown in this preparation. Approximately × 500.


9


10


11

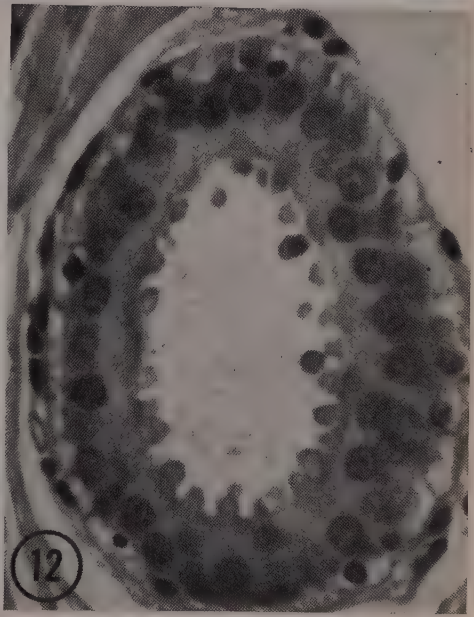

12

PLATE 4

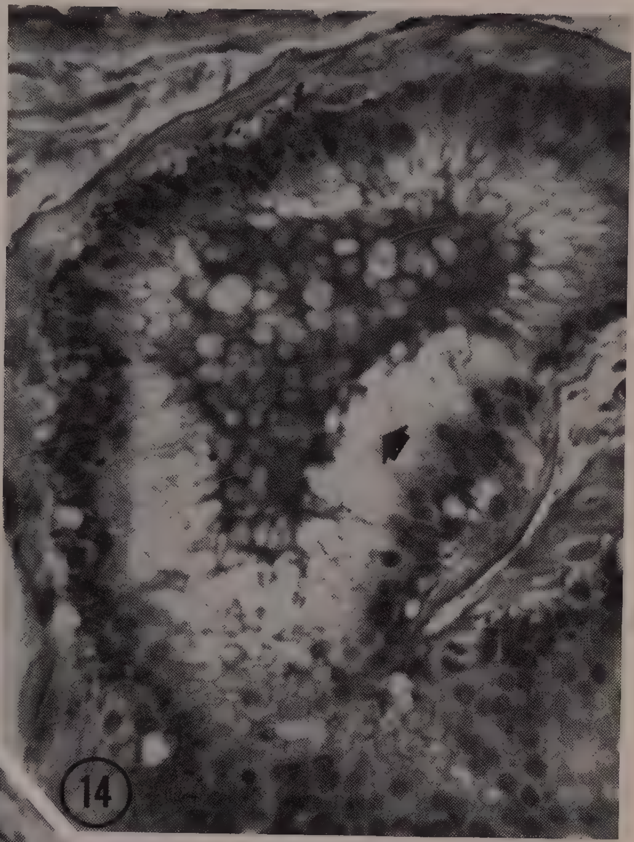
EXPLANATION OF FIGURES

13 Alkaline phosphatase in the apocrine gland in the skin lateral to the brachial organ. Contrast this figure with figure 18. Approximately × 50.

14 Section through one of the glands of the brachial organ, showing the very tall epithelium. This preparation was treated with the PAS reaction, and shows the content of the lumen moderately PAS-positive, and scattered through it are PAS-negative globules. Similar globules are also found intracellularly (arrow). Compare with figure 15. Approximately × 350.

15 Section through a gland of the brachial organ prepared with the PAS reaction. The arrow points to the junction of the gland with the duct. This portion of the duct contains some glycogen. The content of the lumen of the gland is strongly PAS-positive, but it still contains a few PAS-negative globules. Approximately × 350.

13


14

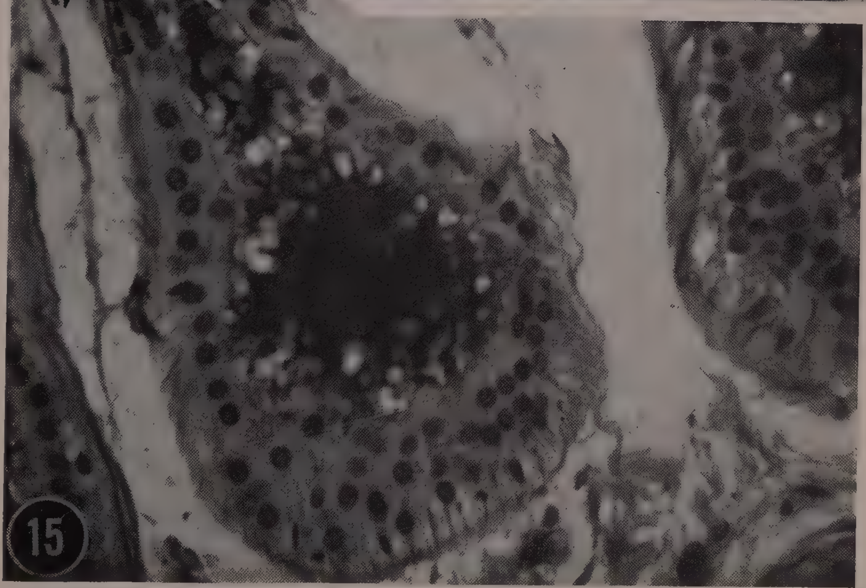

15

PLATE 5

EXPLANATION OF FIGURES

16 Frozen section of skin of the medial side of the arm treated to demonstrate phosphorylase activity. The arrow points to the ducts of one of the glands which opens to the surface of the skin independent of hair follicles. The gland is strongly reactive for phosphorylase. Approximately × 50.

17 Frozen section of the skin of the medial side of the arm, treated to demonstrate nonspecific esterases. Strong esterase activity in the surface epidermis, in the pilary canals, and in the sebaceous glands. The apocrine glands are very strongly reactive, but their duct is not (arrow). Approximately × 50.

18 Strong alkaline phosphatase activity in the glands of the brachial organ. Compare this with figure 13. Approximately × 50.

16

17

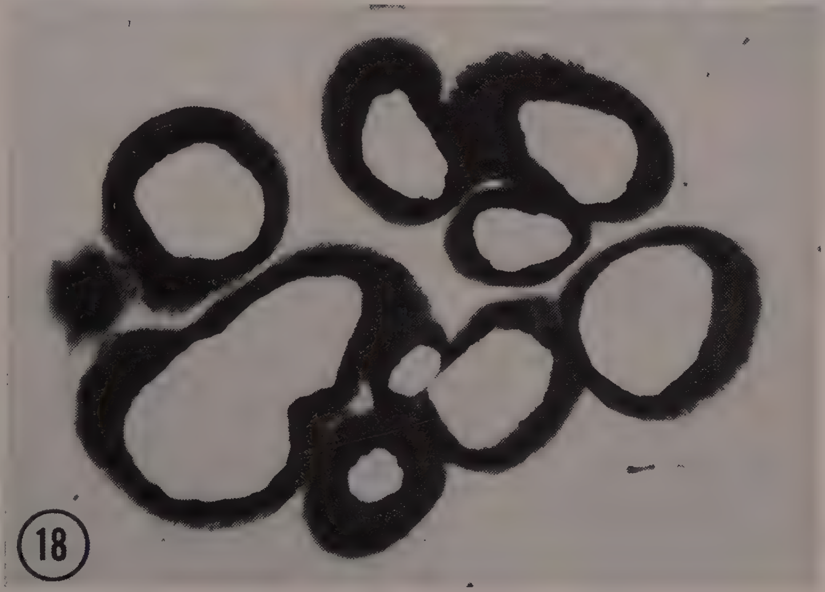

18

PLATE 6

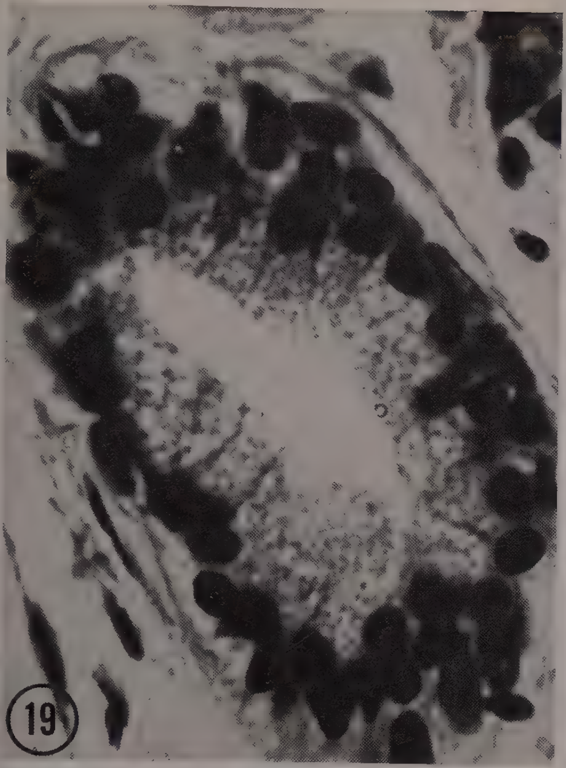
EXPLANATION OF FIGURES

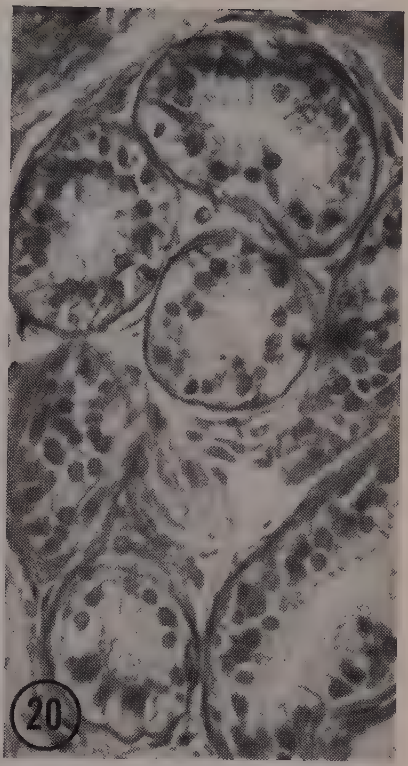
19 Transverse section through the secretory portion of an eccrine sweat gland from the palm, stained with toluidin blue buffered to pH 4.5. The nuclei are all pressed at the base of each cell, and the cytoplasm is full of very lightly stained granules between which are strongly basophil granules. These cells resemble mucus secreting cells. Approximately × 500.

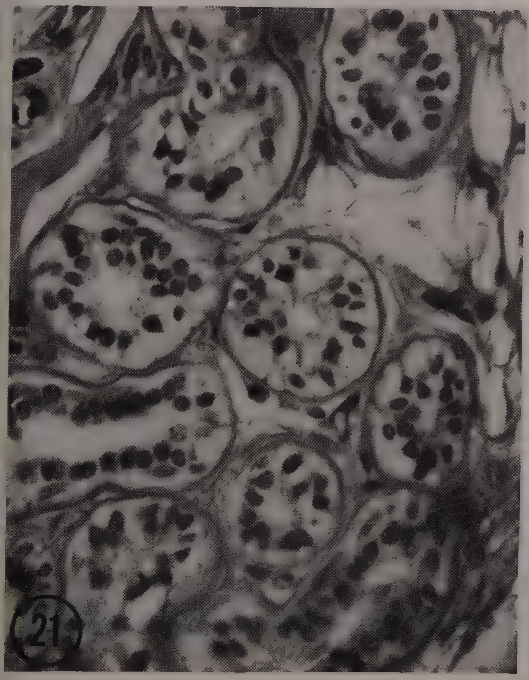
20 Section through some of the coil of an eccrine gland from the palm, treated with PAS. There are no glycogen or other PAS-positive granules. Approximately × 100.

21 As in figure 20, but digested with saliva before being treated with PAS. There are no PAS-positive, saliva resistant granules. Compare with figure 20. Approximately × 100.

22 Frozen section of the palm showing phosphorylase activity. The epidermis (white arrow) has moderate activity, the duct of the gland has better activity, and the coils of the tubules (curved arrow) have the strongest reaction. Approximately × 50.


19


20


21

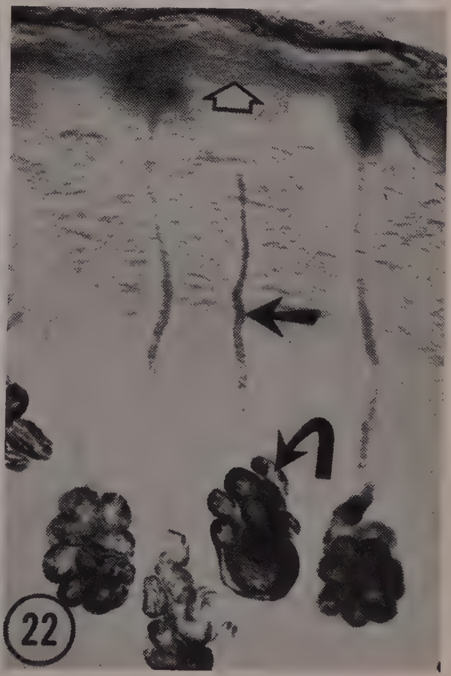

22

PLATE 7

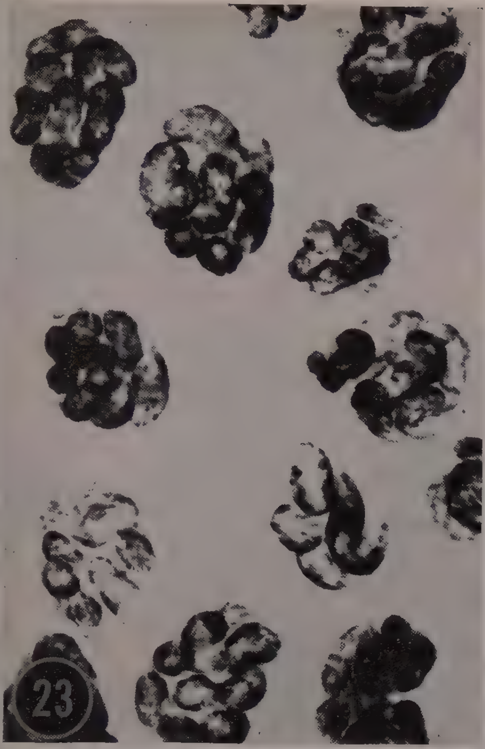
EXPLANATION OF FIGURES

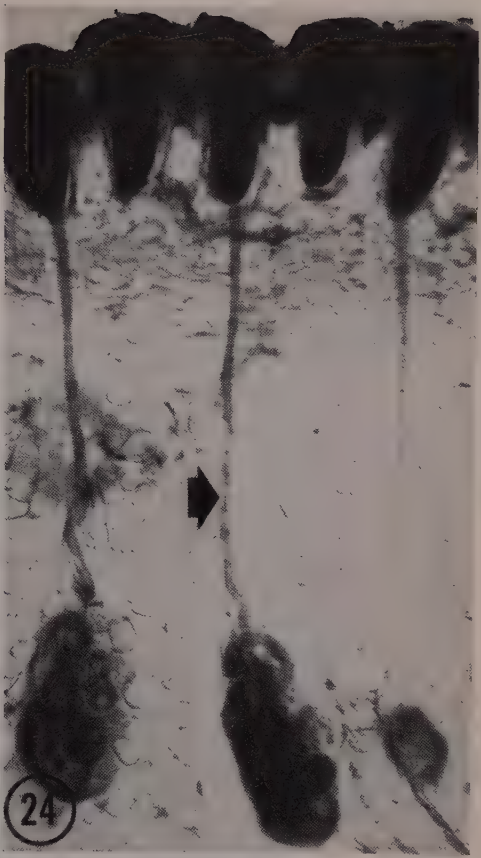
23 Phosphorylase activity in the secretory coils of the eccrine glands of the palm. This is a frontal section through the secretory tubules of the glands. The reactivity in the tubules is strongest toward the periphery, or in the myoepithelial cells. Approximately × 75.

24 Thick frozen section through the palm showing nonspecific esterase activity. The epidermis and the epidermal ridges are intensely reactive. The ducts of the eccrine glands (arrow) are weakly reactive and the secretory coils of the glands are moderately to strongly reactive. Contrast the relative diameter of the secretory tubules with that of the ducts. Approximately × 50.

25 Section through the palm, showing acetylcholinesterase, lightly counterstained with paracarmine. The corpuscles of Meissner (white arrows) are intensely reactive but the nerves that emerge from them are not. The secretory coils of the sweat glands are surrounded by reactive nerves but the ducts (black arrows) are not. Approximately × 50.

26 Higher magnification of the same preparation showing a greater detail of the nerves surrounding the secretory coils of the eccrine sweat glands. The ducts (arrow) contain no visible nerves around them. Approximately × 100.


23


24

25

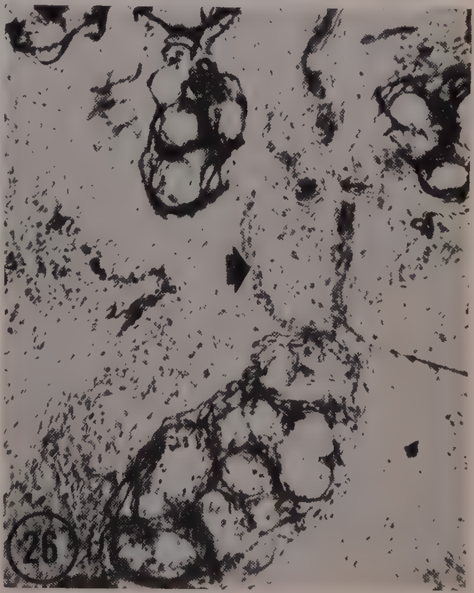
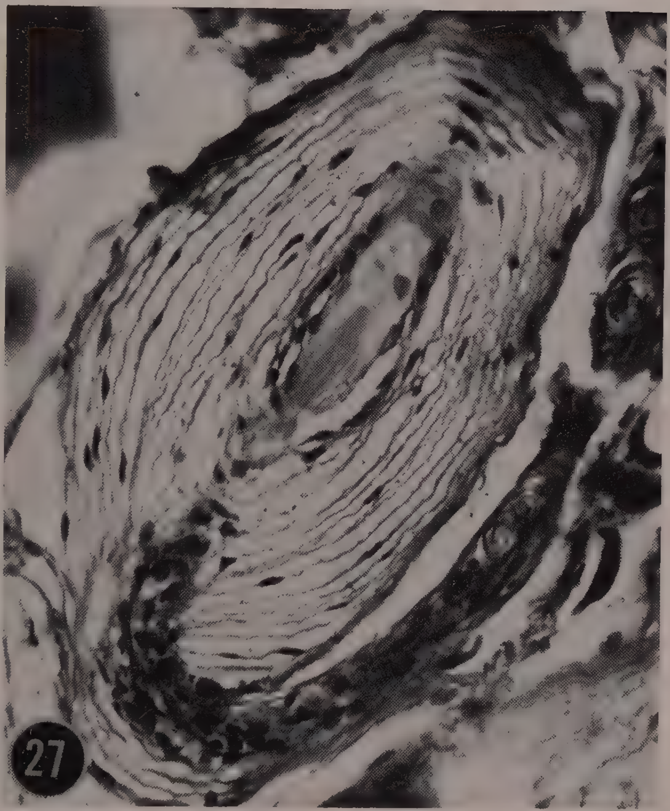

26

PLATE 8

EXPLANATION OF FIGURES

27 Pacinian corpuscles from the palm, stained with the PAS technique and counterstained with hematoxylin. The general configuration of this corpuscle is like that of most other mammals, but the central body is very large and mildly PAS-reactive. Approximately × 250.


27

opulational Analysis of Finger and Palm Prints in
ighland and Lowland Maya Indians[1]

MARSHALL T. NEWMAN
Division of Physical Anthropology, U. S. National Museum
Washington, D. C.

In 1947 and 1949 T. D. Stewart ('47)
nducted anthropometric surveys of 4
aya-speaking communities in the Guate-
alan Highlands, with the view of discern-
g their biological relationship to the Low-
nd Maya of Yucatan. Included in his
ld studies were finger and palm prints of
e same people that were measured. The
udy of these prints was begun by Harold
mmins, but the press of other duties
evented him from completing more than
out half the formulations so the remain-
g formulations and the analysis were
rned over to me.

Early in his Guatemalan work Doctor
wart realized that the problem not only
olved measures of biological distances
ween Highland and Lowland Maya, but
o differences between his 4 Highland
nples. This order of problem, however,
much more restricted than in the usual
rmatoglyphic studies where comparisons
samples are almost invariably broad and
ercontinental in scope. Within the abo-
inal Americas, for example, Cummins
l Midlo ('43, pp. 259–264), Wolfe ('50,
4), and Rife ('53, p. 324; '54, table 3)
used very gross geographic divisions
responding to the Eskimo and the North,
ldle, and South American Indians. The
ncipal measures of expression of the
mal ridge patterns used in these studies
themselves rather gross and were de-
ned to distinguish the large blocks of
nkind rather than for comparison of
ulations.

deally the best dermatoglyphic solu-
ns to such population problems call for
re sensitive methods of analysis than
currently available. But development
ptimal methods for populational anal-
would entail detailed examination of
ny facets of an active research field
that goes back to Galton and represents a major undertaking. In any event, it seems proper to first test the established methods on the new populational medium. In itself this approach requires more information than is usually available on the nature of the dermatoglyphic samples and the populations from which they were drawn. Fortunately for the present study, Stewart recorded the name, sex, age, birthplace, and language for each subject, and has anthropometric measurements and in some cases ABO and MN blood groups for them. To this extent, then, the natures of the samples are known. Place of birth data, combined with what is known or can be reasonably inferred about the communities, provide information on the populations themselves. Some idea of the past relationships of these populations can be inferred from pertinent portions of the archeological record and from modern linguistic analysis.

The present paper, then, shows what can be accomplished by established dermatoglyphic methods in discerning the biological distances between Maya populations. In addition to considering the natures of the samples and their parent populations, statistical means of appraising the significance of intersample differences have been brought into play. Matters of variability within each population sample, however, are not as readily approached by the established methods. For the samples under study, the standard deviations of the two prinicipal determinants are either so uniform as to hold no hope of significant differences or are distorted by errors inherent in small samples (see tables 1 and 3).

---

[1] Based on materials collected by T. D. Stewart.

MATERIALS AND METHODS

The Highland Maya samples Dr. Stewart obtained in Guatemala (see fig. 1) are:

1. *Soloma (San Pedro Soloma).* A small village of under 1,000 people in the Cuchumatanes Mountains, Department of Huehuetenango. These people speak the Kanhobal (Kanjobal) language of Maya. Of the 91 males for which prints are available, 83 were born in Soloma, 5 in neighboring Santa Eulalia, and three in San Juan Ixcoy. Twenty-four of the 25 femal were born in Soloma, one in Santa Eulali

2. *Sololá.* A large town on the nort side of Lake Atitlán, Department of Solol According to McBryde ('45, p. 98), 3 years ago the population of Sololá wa 11,319, including a sizable proportion (racially mixed Ladinos. At Sololá, Ca chiquel is spoken. In the male series (82, 77 were born in Sololá, three in Sa Jorge de Laguna (an aldea of Sololá c the lake) and two in Canton Chuiquel an

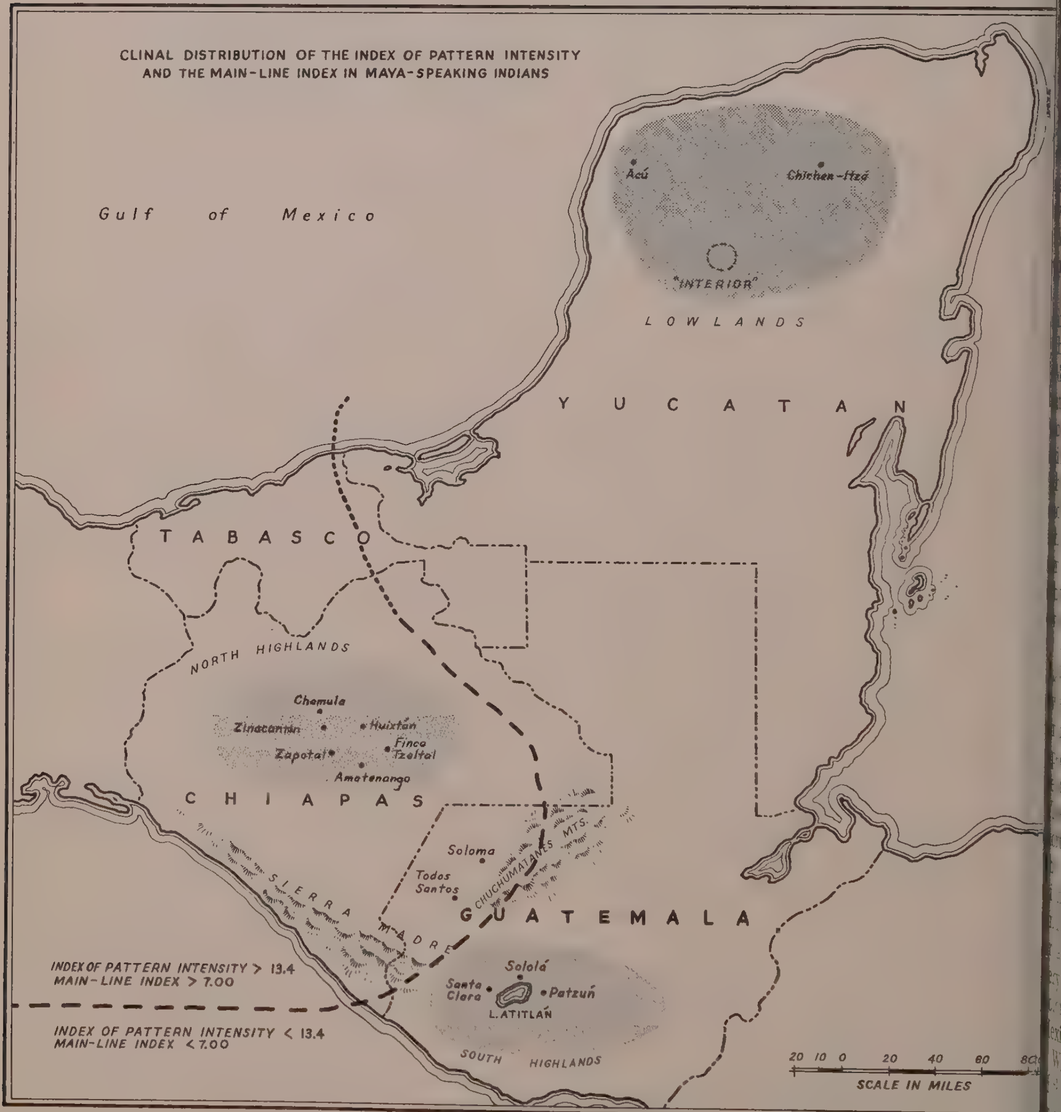


Figure 1

aisiguan (caserios of Sololá). No prints women were obtained.

3. *Patzún.* A medium-sized town on e eastern edge of the Lake Atitlán Basin, epartment of Chimaltenango. Like lolá, Cakchiquel is also the language oken. Of 72 males in the sample, 70 ere born in Patzún, two in Panimaquin d Chipiasol (caserios of Patzún). All of e 35 females were born in Patzún.

4. *Santa Clara la Laguna.* A rural com- unity just northwest of Lake Atitlán and the Department of Sololá. The language oken there is Quiché. According to Mc- ryde ('45, p. 98), the 1921 census lists population of 1,428. Fifty-three of the 9 males were born in Santa Clara, 9 in nta Lucia Utatlán nearby, and one each Santa Maria Visitación, Totonicapan, d San Pedro (Jocopiles). Two more ere born in Finca Horizonte and Baja sta near Chicacáo in the adjacent depart- ent of Suchitepequez.

All population samples, then, are adult d therefore for the most part represent e actual breeding population. All speak aya. The Soloma people speak Kanhobal, Sololá and Patzún Cakchiquel is spoken, d Quiché is spoken at Santa Clara. Ra- ally they are Indian, but with a definite ough probably minimal amount of White lmixture. Dr. Stewart indicates that al- ough he took his subjects as they came were unwillingly brought to him, any at were obviously admixed with Whites ere rejected or noted in the records.

All but the Soloma sample are from the ke Atitlán Basin. The air distances be- een Santa Clara and Sololá, and Sololá d Patzún are about 10 and 15 miles, re- ectively. All three communities are cur- ntly interconnected by routes of trade. e village of Soloma, however, lies to the rth in the San Juan River drainage of e rugged Chuchumatanes Mountain re- on, and is quite separate topographically d commercially from the Lake Atitlán ea. As we shall see, the cultural and ry probably the racial relationships of loma lie to the north and across the exican border into Highland Chiapas.

While it is not wholly clear that each the 4 communities constitutes a natural breeding population, there is a strong ference from Stewart's place-of-birth data that this is the case. This inference is supported by Lasker's ('54, p. 358) statement that "In contemporary Middle America it appears usual that the populated place, whether *rancho, pueblo,* or *cabecera,* is coextensive with the breeding community." Except for two individuals studied in the hamlet of Santa Clara La Laguna all subjects were locally born. Almost all subjects, then, were born in the community studied by Stewart, or in caserios or other habitation units dependent upon that community. This bespeaks local endogamy and current population stability, although nothing is known of the situation in past generations.

Size of population varies considerably for the 4 samples. Soloma and Santa Clara are small rural settlements of 1000–2000 people, and Patzún and Sololá are considerably larger. While population size does not appear to be reflected in the samples, at least within the scale of analysis of them, there are two possible effects. In theory, any effect of random genetic drift may be minimal in the larger populations, especially if offset by gene flow (cf. Lasker, '54, p. 360). Yet it is there in the larger population centers that Ladinos are numerous, and opportunities for inflow of White genes into the Indian populations could expectably be heightened.

Linguistically the Soloma population is set off by itself. According to McQuown ('56, p. 195), Kanhobal, along with Jacaltec and Solomec, form the Kanhobalan subgroup of Maya languages. Cakchiquel and Quiché, with three other languages, make up the Quichean sub group. No glottochronological data are available on the time of separation of these subgroups or the languages within them. Inferentially these times of separation need not have been very long ago since Huastec, the most different language in the Maya family, and Cakchiquel have a calculated minimum divergence of 3600 years (Swadesh, '58, p. 672). For Cakchiquel and Quiché, McQuown's ('56, p. 195) classification and their proximity and extensive trade relationships suggest that these two languages had a not too distant common origin.

On the basis of archeological materials, there is a clear-cut separation between the region north of the Chuchumatanes escarpment and the Lake Atitlán region (Stephan F. Borhegyi, personal communication). In Borhegyi's ('56, fig. 107) map, both are designated as Area C principally because this whole area appears to have been relatively uniform in the Pre-Classic horizon (2000 B.C.–200 A.D.). This uniformity progressively broke down in the succeeding Classic (200–1000 A.D.) and Post-Classic (1000–1524 A.D.) periods. Thus for these last two periods, Borhegyi would now divide Area C into two subsections corresponding to the Highland area of Guatemala and Chiapas north of the Chuchumatanes escarpment, and the Lake Atitlán Basin. On the modern level, McBryde ('45, p. 7) notes that "there are certain cultural characteristics of the Chuchumatanes region that resemble the Las Casas region of Chiapas (Mexico) and that distinguish it somewhat from the rest of Guatemala." The line of cultural, linguistic, and probably racial separation, then, is the steep southern escarpment of the rugged and extensively dissected Chuchumatanes mountains, the highest massif in Central America. Linguistically, the south Chuchumatanes escarpment and part of the Sierra Madres separates Tzeltalan, Chuh, Kanhobal, and Mam to the north from Quichean and Kekchian to the south. Only Quiché is found on both sides of this barrier (Siverts, '58, p. 178). The probable biological separation at the Chuchumatanes barrier is one of the several main points to be developed in the present paper.

In the ensuing analysis, male and female samples are treated separately in comparing the 4 Guatemalan Highland samples. Since female samples are small in size and are only available for Soloma and Patzún, they are useful largely in confirming or negating the direction of differences between the male samples from these communities. The broader regional comparisons between Highland and Lowland Maya depend upon published series where males and females have been considered together (Cummins and Steggerda, '36; Steggerda et al., '36). Accordingly, for these comparisons the female samples collected by Stewart have been pooled with their male counterparts.

In addition, for these broad regional comparisons other samples collected by Stewart were utilized. Although too smal
in number to be considered by themselves
these samples were added to their appro
priate regional sample. Thus a sample o
13 Mam-speaking males from Todos Santo
Cuchumatán and environs was place
with the Soloma sample and the 5 High
land Chiapas samples (Leche, '36; Lech
et al., '44) to form a North Highland
regional sample. Samples of 12 misce
laneously located Quiché-speakers, 10 Cak
chiquel and three Zutuhil were added t
the South Highland (Lake Atitlán) re
gional sample.

The methods used here in formulatin
the finger and palm patterns follow th
instructions of Cummins and Midlo ('4
chaps. 4 and 5). Since Cummins himsel
had already formulated the palm pattern
for the Sololá and Patzún samples, thes
were carefully restudied to afford greate
consistency in formulating the rest. Fo
the finger patterns, formulations were fir
made for the subtypes of the standar
whorl-loop-arch designations (Newma
'36, table 1). The expectation was th
these subtypes might show significa
interpopulation differences where the thre
gross designations might not. In the cour
of formulation, however, it became appa
ent that the subtypes could only be a
curately diagnosed when the print of th
individual was wholly clear. But in prin
ing, the scarred and calloused finger-tips
uncooperative subjects often result in i
distinct and smeared patterns only d
cipherable by the gross designation
whorl, loop, or arch. For this reason th
incidences of pattern subtypes that are d
cipherable are as much an artefact
printing as they are biologically meanin
ful figures. Thus finger pattern subtyp
were not used in the ensuing analys
Ridge counts were precluded for the sa
reasons.

As Cummins (personal communicatio
has pointed out, artefacts in printing c
also affect the incidence of hypothenar p
terns on the palm. Unless the palm is ca
fully rolled ulnar-side first across the pri
ing paper, the hypothenar pattern that
present may not be secured at all.
consequence the absence of a pattern
recorded although one is actually there.

Selection of dermatoglyphic determinaons has been based upon the principle of rsimony as well as upon demonstrated ility in published comparisons on New orld series. Thus the *index of finger ttern intensity*

$$\frac{(2 \times \% \text{ whorls} + 1 \times \% \text{ loops})}{10}$$

a good general indicator of the proporon of highly expressed patterns, namely horls, to essentially no patterns at all, as r example arches. This index is based on the same idea as the indices of Furuta's ('27) and others, and therefore the e of more than one index is unnecessary plication. Further, the index of pattern tensity shows regular regional reductions om the Eskimo to North American Inans, and then to Indians of Middle and uth America. Thus it shows biologically eaningful differences between groups of pulations similar to those involved in e present study. Besides, although stational validations of differences between ean indices of pattern intensity have en little used, the index is susceptible to is sort of treatment if the standard deation of individual intensity scores ound the mean are known. These indidual scores for the sum of 10 digits of ch individual in the sample can be callated by giving the value of two to each horl, one to each loop, and zero to each ch. Then the differences between means samples can be compared in terms of e value of *t* in a probability table where

$$t = \frac{M_1 - M_2}{\sigma M - M_2}, \text{ and}$$

$$\sigma M_1 - M_2 = \sqrt{\frac{(N_1 + N_2)(N_1\sigma_1^2 + N_2\sigma_2^2)}{N_1 N_2((N_1 - 1)+(N_2 - 1))}}.$$

and M_2, and σ_1 and σ_2 are the means d standard deviations of the two samples; N_1 and N_2 are the number of subts in each of the two samples. Given a lue for P from the probability table, there ly remains the quite arbitrary decision to what level of confidence constitutes statistically significant difference been M_1 and M_2. In practice a statistically nificant difference is usually assumed be a biologically significant one, alough this may not necessarily be so.

The most generally used measure of the rmal ridge configurations of the palm is the *main-line index.* This index is an arbitrary expression of the proximal terminations of the triradii at the base of the second and fifth fingers, known as main-lines A and D. It is therefore not a proportion or a series of categories, but ". . . a summation of values describing the courses of these two main lines" (Cummins and Midlo, '43, p. 114). Although main-line D terminations are assigned values equivalent to those of main-line A in terms of their transverse or longitudinal character, the association between their courses is not a rigid one. Thus main-line D could terminate in position 11, and main-line A in position 1 for the same hand. The arbitrary values, respectively, are 6 and 1, totaling 7. The same formulation of 7 can also be achieved in other ways; for example, main-line D could terminate in position 9 (value of 4), and main-line A in position 3 (value of 3). It is precisely this variability of values resulting in the same score for individual formulations that prompted one of my colleagues trained in statistics (Gordon Gibson) to question whether average main-line indices for two samples are susceptible to comparative statistical treatment at all. In this sense, simple comparison of unguarded means is also a statistical manipulation. Statistical procedures in this instance would be better satisfied, according to Dr. Gibson, if the values for one and not two main-lines were summated into an index or a proportion. The *type 11:7 ratio*, then, would be a statistically unobjectionable device, since it simply expresses the relation of two modal types of terminations for main-line D. Yet this ratio shows little or no distributional regularities in American aboriginal samples, and is considered an inferior measure to the main-line index by Cummins and Midlo ('43, pp. 113–114). For these reasons any attempt to devise a statistically acceptable measure of palmar main-line direction from one main-line alone is not likely to produce as meaningful a measure as the main-line index. There is no question that Gibson is right in withholding statistical approval from so composite a measure as the main-line index. Future research for the purpose of developing more sensitive dermatoglyphic tools should more closely adhere to the tenets of good statistical procedures than they have in the past. But since this paper is concerned with the application of the established dermatoglyphic methods to populations, it seems best to use the main-line index even though this tends to violate statistical usage.

In short, use of the *main-line index* is statistically suspect, yet it does have definite meaning. A high average *main-line index* bespeaks a strong trend toward transverse (across the palm) courses of the two outside main-lines, while a low mean index signifies their generally longitudinal (proximo-distal) direction. The distributional significance of the index in American aborigines is by no means clear, although the present paper provides some clarification in its area of interest. Cummins and Midlo ('43, table 148B) show the highest main-line indices as occurring in Eskimo, the next highest in Middle American Indians, and the lowest in North American Indians.

Finally the presence of patterns on the 5 areas of the palm can be expressed as simple percentages. These percentages represent catch-alls for all sorts of configurations ranging from "vestigials" without definite form to fully developed whorls. In rather small samples such as used here, direct comparison of palmar pattern subtypes is not likely to be fruitful. Accordingly, the simple occurrences of patterns are used here for comparative purposes and are restricted to the hypothenar and thenar-first interdigital areas as probably the most meaningful. Cummins and Midlo ('43, fig. 146) have shown a rather slight diminution in frequencies of hypothenar patterns from Eskimo to North American Indians, with Middle American Indians lowest. Much more striking is the very strong rise of thenar-first interdigital pattern incidence in Middle American Indians over that of any other New World aborigines (Cummins and Midlo, '43, fig 146). No comparable gradations have been noted for pattern incidences in the second third and fourth interdigital areas. In the present paper, frequency differences in occurrence of palmar patterns are tested by the χ^2 method for a 4-fold table.

Internal Relationships of the 4 Guatemalan Highland samples

Index of pattern intensity. Percentage of the main finger pattern designation (table 1) show the Soloma males and females to have more whorls and fewe arches than any of the other samples. These percentages are expressed in the index of pattern intensity, which is als higher in the two Soloma samples. A evaluation of the statistical significance o the mean differences in this respect between pairs of male samples is provided i table 2. The female samples are too smal in size to merit this statistical treatmen The differences between the three Lak Atitlán Basin samples (Santa Clara, Solol and Patzún) and the more northerly situated Soloma sample are probably significant. Where P = 0.001 between Solom and Patzún, the chances that their mea differences could occur within the sam population are 1 to 1000, a surely significant difference. Between Soloma an Sololá (P = 0.0138), and Soloma an Santa Clara (P = 0.0384) the levels significance are less sure. It then becom

TABLE 1

Percentages of finger pattern designations and mean indices of pattern intensity in Guatemalan highland indians

Sample	No.	Whorls	Radial loops	Ulnar loops	All loops	Arches	Index of pattern intensity	
							Mean	S.D.
Males								
Soloma	90	48.7	2.5	46.3	48.8	2.4	14.50	3.43
Santa Clara	68	39.5	3.2	51.6	54.9	5.6	13.25	3.70
Sololá	82	40.0	3.7	50.0	53.7	6.3	13.10	3.83
Patzún	72	34.8	2.9	55.4	58.3	6.9	12.59	3.90
Females								
Soloma	22	43.1	1.6	53.2	54.9	2.0	14.23	2.89
Patzún	32	36.1	1.2	48.7	49.9	14.0	12.47	4.58

TABLE 2

Paired mean differences and their chance probabilities (P) in the index of pattern intensity (Males)

	Sample	Mean differences			
		Soloma	Santa Clara	Sololá	Patzún
	Soloma	——	1.25	1.40	1.91
P	Santa Clara	0.0384	——	0.15	0.66
	Sololá	0.0138	0.8180	——	0.51
	Patzún	0.0010	0.6030	0.4066	——

quite arbitrary matter to decide whether -4 chances in 100 are adequate odds voring significant differences.

Between the three Lake Atitlán Basin mples the probabilities are very high (40 80 out of 100) that the mean differences uld be due to chance. Thus as far as ger pattern intensity goes, these three mples appear to have been drawn from e same population. Furthermore, the uiché sample from Santa Clara and the kchiquel sample from Sololá have al- ost identical mean indices of pattern in- nsity, and are closer in this respect than ther are to the other Cakchiquel sample om Patzún. In a statistical sense these uiché-Cakchiquel relationships are all n-significant, but it is barely conceiv- ble that the hamlet of Santa Clara where uiché is now spoken had closer historical d genetic relations with Sololá at the ad of Lake Atitlán than with Patzún on e other side of it.

Main-line index. Although the main- e indices of the Guatemalan Highland mples cannot be statistically compared, ere is nevertheless some merit in exam- ing the unguarded means. These, with eir standard deviations, are listed in ble 3. There is a fairly regular progres- n of male means, with Soloma the high- t and Patzún the lowest. This Soloma- tzún difference in the male samples is t corroborated by their female counter- rts, which have identical main-line indices. Whether this lack of confirmation is real, or is due to errors of sample in the much smaller female series constitutes an unanswerable question. At any rate, small as the mean male difference between 7.35 and 6.72 may appear, it is over one-third of the mean range for the world (cf. Cummins and Midlo, '43, fig. 148B). Biologically speaking, then, the main-line indices considered here only seem to have relevance when viewed in the larger distributional pattern.

It is notable that a higher index of finger pattern intensity (more whorls, fewer arches) and a higher palmar main-line index (greater transversality of main-lines) go along together in the more northerly Soloma male sample. Both these higher mean indices are quite in keeping with those typifying the Tzotzil- and Tzeltal-speaking Maya even further north in Highland Chiapas. This distributional pattern north of the south Chuchumatanes escarpment is discussed more fully on pp. 53–54 and is only mentioned here as evidence that the main-line indices are meaningful in a biological sense, although their differences cannot be statistically validated.

Thenar-first interdigital and hypothenar patterns. The percentage occurrences of thenar-first interdigital patterns are listed in table 4. In that table the high percentage of patterns (54.5%) for the Soloma males differs perhaps significantly at $P < 0.01$ from the low percentage (34.8%)

TABLE 3

Mean main-line indices of Guatemalan Highland Indians

Males								Females			
Soloma (89)		Sololá (82)		Santa Clara (69)		Patzún (72)		Soloma (24)		Patzún (35)	
Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
7.34	2.28	7.20	2.03	6.83	2.09	6.72	2.26	6.90	2.73	6.92	2.21

TABLE 4

Means and percentages for dermatoglyphic data by region and by sample for Maya Indians from Mexico and Guatemala

Region and sample		Area	Language	No.	Index of finger pattern intensity	Main-line index	Thenar-1st Interdigital patterns	Hypothenar patterns
							%	%
North Highlands				420	14.4	7.26	45.8	14.2
Amatenango	M[1]	Highland Chiapas	Tzeltal	49	15.4	7.23	41.8	18.4
Zinancan	M[1]		Tzotzil	24	14.7	7.31	43.7	14.6
Huixtán	M[1]		Tzotzil	50	14.6	7.43	44.6	11.3
Chamula	M[2]		Tzotzil	100	14.0	7.73	40.5	14.0
	M[1]		Tzeltal	47	13.7	6.63	47.1	16.1
Tzeltal-Tzotzil	[3]		Tzeltal-Tzotzil	23	14.2	6.67	45.6	6.5
Soloma	M	North Highland Guatemala	Kanhobal	90	14.5	7.34	54.5	13.5
Soloma	F		Kanhobal	24	14.2	6.88	41.7	20.8
Various	M		Mam	13	16.0	6.62	53.8	11.5
South Highlands				272	13.1	6.89	42.0	10.3
Santa Clara	M	Lake Atitlán Basin	Quiché	68	13.2	6.83	34.8	11.6
Sololá	M		Cakchiquel	82	13.1	7.20	45.1	11.6
Patzún	M		Cakchiquel	72	12.6	6.72	40.6	9.1
Patzún	F		Cakchiquel	35	12.5	6.88	45.7	11.4
Various	M		Quiché-Cakchiquel, Zutuhil	25	13.3	6.51	50.0	4.0
Lowland Yucatan				152	12.6	6.66	46.4	12.4
Hda. Acú[4]	M	Northern Yucatan	Yucatec	25	12.7	6.96	40.0	20.0
"interior"[5]	M		Yucatec	21	—	6.93	40.5	4.0
Chichen Itza[6]	M + F		Yucatec	127	12.6	6.56[7]	48.7[7]	12.3[7]

[1] Leche et al., '44.

[2] Leche, '36.

[3] Cummins, '32.

[4] Leche, '33.

[5] Cummins, '36. Referred to as "Maya Quiché" by Cummins ('30, p. 123).

[6] Cummins and Steggerda, '36; Steggerda et al., '36.

[7] 224 in the palmar sample.

r the Santa Clara males. None of the
her pairs of differences can be considered
gnificant, as the following list of prob-
ilities attests:

Soloma-Sololá $P < 0.3$
Soloma-Patzún $P < 0.2$
Sololá-Patzún $P < 0.7$
Sololá-Santa Clara $P < 0.2$
Patzún-Santa Clara $P < 0.6$

The percentages of hypothenar patterns
so listed in table 4 are in keeping with
e somewhat higher expression of thenar-
st interdigital patterns in the Soloma
ries, but are themselves of doubtful sig-
ficance. The progression of hypothenar
ttern occurrence is from Soloma (both
mples) to Sololá and Santa Clara with
entical figures, with Patzún the lowest.

Relationships between Highland and Lowland Maya

The means and percentages for the prin-
pal dermatoglyphic determinations in all
ailable Maya Indian samples are given
table 4. These samples are also grouped
gionally as North and South Highlands
d Lowland Yucatan. As explained on
48, the dividing line between the
orth and South Highlands is a real rather
an an artificial one; it is the steep south-
n escarpment of the Chuchumatanes
assif and part of the Sierra Madre which
ems to have served as a partial linguistic
d cultural barrier. An important premise
re is that this escarpment served as a
rtial biological barrier as well.

Index of pattern intensity. It is clear
om the weighted regional means that the
ttern intensities in the fingers are high-
t in the North Highlands and lowest in
e Yucatan Lowlands. The significance
this difference between the regional
eans cannot be tested because standard
viations are not available for the 5
ghland Chiapas samples. To carry out
e statistical testing anyway, it has been
sumed that the mean and standard de-
ation of the combined Soloma and Mam
mples are reasonably representative of
e North Highlands as a whole. In con-
quence, much of the ensuing argument
nges upon this assumption.

With the Soloma-Mam sample stretched,
it were, over this broad area, the mean
ttern intensity indices for the North Highlands, South Highlands, and Yucatan Lowlands are 14.56, 13.10, and 12.57, respectively (table 5). Table 6 shows that the North Highland Maya are very significantly separated from those of the other two regions by mean differences with P of 0.0001 to 0.0002. On the other hand, the South Highland (Lake Atitlán Basin) and the Yucatan Lowland Maya do not differ significantly in this respect ($P = 0.08$). There would seem to be a break in pattern intensity, with the dividing line arbitrarily set at about 13.4, running along the southern Chuchumatanes escarpment and thence gradually north to the Gulf. North of this line are the higher mean indices of pattern intensity; south of it are consistently lower ones (fig. 1). The extension of this southerly region of low pattern intensity beyond the Maya cannot be gauged because of lack of data. No dermatoglyphic samples of Indians are available for those between Southwest Guatemala and the Sierra de Perijá in Venezuela. For the latter area, Geipel's ('55) patently inadequate sample of 18 Yupa (Motilone) have a mean index of 12.9. Further south along the West Coast a sample of 207 North Peruvian Quechua have a mean of 12.9 (Newman, ms.), and further still 246 Araucanian Mapuche average 13.0 (Henckel, '33). In the South American tropical forest some samples

TABLE 5

Means and standard deviations for index of pattern intensity in regional groupings of Maya Indians

Region	No.	Mean	S.D.
North Highland[1]	120	14.56	3.36
South Highland[2]	272	13.10	3.91
Lowland[3]	127	12.57	3.44

[1] Soloma males and females; Mam males (12).
[2] Lake Atitlán Basin—Santa Clara, Sololá, and Patzún males; miscellaneous other Quiché, Cakchiquel, and Zutuhil males (24).
[3] Chichen Itza males and females.

TABLE 6

Paired mean differences and their probabilities (P) in the index of pattern intensity

Region	North Highland	South Highland	Lowland
North Highland	———	1.46	1.99
South Highland	0.0002	———	0.53
Lowland	0.0001	0.0818	———

have higher finger pattern intensities, so the distribution for the whole southern continent is unclear.

Main-line index. The regional weighted means for the main-line index in table 4 partly corroborate the division between the North and South Highlands so clearly seen in finger pattern intensities. Thus the Soloma males have a main-line index of 7.34, very close to the North Highland weighted mean of 7.26 and distinctly higher than all but that of the Sololá sample from the South Highlands. For the other principal samples in the North Highland region, all those from Chiapas but the 47 Finca Tzeltals have indices well over 7.00. These higher main-line indices also characterize other Mexican Indian samples—Zapotec, Mixtec, Tarascan, and Aztec—and suggest a wide area of more transverse palmar main-lines that extends up to Northern Mexico.

This broad area of higher main-line indices, then, extends from Central Mexico to the Chuchumatanes escarpment in Northern Guatemala. The break between North and South Highlands is not wholly clear because of the Finca Tzeltal and Sololá samples, but the remainder of the South Highland and Yucatan Lowland samples all have mean indices below 7.00. South of the Maya area there is so little information on main-lines that it is hazardous to extend this low index area into South America. The 230 North Peruvian Quechua (Newman, ms.) have a mean main-line index of 6.94; Keith's ('24) 63 Quechua and Aymará from South Peru average 7.09. The distribution of the main-line index over the rest of the southern continent is unknown.

In the Yucatan Lowland region, the two small Maya samples tend to confirm the very low (6.56) main-line index of the Chichen Itza sample. This is the lowest mean index on record for American Indian samples of adequate size.

The regional weighted main-line indices for the North Highlands, South Highlands, and Lowlands are 7.26, 6.89, and 6.66, respectively. As in finger pattern intensity there is a close correspondence between South Highland (Lake Atitlán Basin) and Lowland Maya than between either one and the North Highlands. The mean differ ences of 0.37 between the North and Sout Highlands, and 0.23 between the Sout Highlands and Lowlands appear conse quential only in the light of the entir American Indian range of 1.38. Thus th correspondence of means between Sout Highland and Lowland Maya is almos twice as close as between those for th North and South Highlands.

Hypothenar and thenar-first interdigita patterns. The weighted regional percen ages for hypothenar and thenar-first inter digital patterns (table 4) show the lowes expression in the South Highland Maya. A tested by the χ^2 method, however, the onl difference of possible significance is be tween the 14.2% of hypothenar pattern in the North Highlands and 10.3% in th South Highlands. Here with $P < 0.02$, th difference may well be statistically sign ficant, although the very real possibility o artefacts occurring during palm printin may render the difference less meaningfu All other paired regional differences in bot hypothenar and thenar-first interdigit pattern incidences are distinctly nonsi nificant.

From a hemisphere viewpoint the inc dences for hypothenar patterns are low i all three Maya regional samples. Suc low pattern expression in this palmar are is very characteristic of American Indian in general (Cummins and Midlo, '43, 262), and the low hypothenar expressio in the Maya is more of a generalized India trait than anything else.

On the other hand, the over 40% pre ence of thenar-first interdigital pattern constitutes a world high already noted b Cummins and Midlo ('43, p. 261). Th high incidence is also present further nort in Mixtec, Aztec, and Tarahumare sa ples. Since such a high incidence has n been found in Tarascans and Zapotec thenar-first interdigital pattern expressio in Mexican Indians is rather irregular. T the south of the Maya area, incomple evidence suggests that high thenar-fi interdigital pattern expression does n extend to South America. In short, hig expression of this particular pattern see especially concentrated in and characte istic of Maya-speaking Indians.

DISCUSSION

Within the Cummins system of dermato-
yphic formulations for the fingers and
lms, the two most reliable racial deter-
inants are unquestionably the index of
ger pattern intensity and the palmar
ain-line index. Biological distance anal-
es of these two determinants, as applied
Maya Indian populations, have produced
ree principal points:

1. The two Cakchiquel and the Quiché
mple from the Lake Atitlán Basin appear
represent one biological population.
oser dermatoglyphic relations between
e two Cakchiquel samples (Sololá and
tzún) than between either one and the
uiché sample (Santa Clara) were not
scerned. Indeed in its reduced finger
ttern intensity and main-line index the
tzún sample shows the closest approach
the Lowland (Chichen Itza) Maya.

2. The apparently single population of
e Lake Atitlán Basin seems closely re-
ted to the Yucatan Lowland Maya, prin-
pally represented by people from around
hichen Itza. While distance precludes
rticipation of people of the two regions
the same breeding population, the in-
rence is strong that they belong to the
me close grouping of such populations.
ologically speaking, this close grouping
populations could have had a common
igin only a few centuries ago.

3. In contrast to the apparently close
nnections between the South Highland
ake Atitlán) and the Lowland Maya,
ose of the North Highlands stand as a
ite separate group of populations. The
emingly abrupt line of separation be-
een North and South Highlands follows
e easterly extension of the Sierra Madre
nge and the southern escarpment of the
uchumatanes Mountains. In addition
serving as a partial barrier to gene flow,
is mountainous line also affords some
ltural and linguistic separation. In the
o main dermatoglyphic determinants the
nhobal-speaking Soloma sample in the
uchumatanes north of this line fits well
th 5 Tzeltal and Tzotzil samples from
ghland Chiapas. Taken together, this
rth Highland regional sample appears
have much closer relationships with the
dians further north in Mexico than with
eir fellow Maya-speakers.

In appraising these results, it is particularly noteworthy that the employment of dermatoglyphic methods originally designed for gross racial comparisons of intercontinental scope seems fully productive on a much more restricted populational level. Analyses by the rather arbitrary means at hand for describing the two sets of minimally adaptive polygenic traits expressed in dermal ridge configurations have produced a quite clear and reasonable pattern of biological distances within the Maya-speaking populations. It is quite possible, of course, that more sensitive methods of dermatoglyphic analysis would permit the discernment of finer populational distinctions, such as between the Atitlán Basin communities. With new methods and better information on the history, demography, and breeding patterns of the communities, a closer approach could be realized to the full potential of dermatoglyphic analysis.

Quite apart from this very real research potential, it is legitimate to ask whether as clear a pattern of biological distances could have been achieved by the other means of estimation currently at our disposal. On the one hand the equally polygenic traits of anthropometry are not as likely to lead to as clear a pattern since most of these traits are susceptible to considerable postnatal alteration by varying environmental influences. Thus a metric comparison of Highland and Lowland Maya might reflect principally the effects of the two environments upon physique. The phenotypic expression of these effects is in part nongenic, and hence would tend to mask biological differences of a genetic nature.

Yet on the other hand, analyses of single gene traits exemplified by the blood group systems may too strongly reflect any recent gene frequency alterations to discern older and more basic biological relationships between aboriginal Middle American communities. A practical case in point is the matter of European gene flow into the aboriginal pool. Stewart saw some phenotypic signs of White admixture in the Indians of Highland Guatemala, and the Steggerdas noted similar signs of European ancestry in the Chichen Itza Maya (Steggerda et al., '36, p. 134). Beyond this, the European-derived blood group genes B and r (cde) crop up occasionally in Maya populations. Aguirre et al. ('53) record gene frequencies of 0.01 for B and 0.06 for r in 237 Guatemalan Highland Maya. Matson and Swanson's ('59) total Maya series of 553 individuals shows gene frequencies of 0.006 and 0.051 for B and r (including cDe), respectively, but there is great fluctuation between community samples in these regards. Goodner ('30) states his Lowland Maya sample from Chichen Itza and Chankom had a gene frequency for group B of 0.001, and he performed no Rh testing. Neither Arteaga's (Arteaga et al., '52) 63 North Highland Maya from Chamula nor Rife's ('32) Lowland Maya from the upper Usumacintla Valley and elsewhere in the peninsula had the gene for B at all. As it stands now, serological studies on the Maya are useful principally in affording broad comparative data for continental syntheses and in providing estimates of White admixture. Whether Matson and Swanson's ('59) information on a large number of blood group systems for the Maya can produce greater time-depth focus on their populational relationships will depend partly upon how successfully the gene frequencies can be adjusted to allow for European and other foreign admixture. Judging by the rather high frequencies of A_2, B, and r in their samples, stripping off this White genic overlay is altogether too uncertain and arbitrary a procedure to contemplate.

There is little evidence one way or the other, but it may be that White admixture in Middle American Indians has less effect on the expression of polygenic traits exemplified in currently used quantifications of dermal ridge patterns than on single gene frequencies as seen in blood groups. There is no internal evidence whatsoever of European admixture in the dermatoglyphic configurations. In fact, evidence that European admixture has had no appreciable effect is strong on two counts: (1) Europeans and Middle American Indians stand at polar extremes in the incidences of hypothenar and thenar-first interdigital patterns. Europeans are high in hypothenar and low in thenar-first interdigital pattern expression, while Middle American Indians are exactly the opposite (2) While Europeans are generally low in finger pattern intensity and rather high in main-line indices, the major split in Maya Indians cuts across the European pattern—higher indices of pattern intensity and main-lines in the North Highlands, lower ones in the South Highland and Lowlands.

Beyond degrees of expression of foreign admixture in single versus polygenic traits there is a very real possibility that the biological distances discerned in their analyses are referrable to quite different time levels. This is what Birdsell ('52, p. 358 had in mind when he stated that, "It i becoming clear that genetically simpl characters, such as are now the only materials available for use in human population genetics, and which are most usefu for studying certain evolutionary processes may on the other hand give biased an blurred impressions of population relationships distant in time and space. For th latter type of analysis, genetically comple traits may serve better, even though the offer little hope of detailed genetic defin tion." Some confirmation of Birdsell' statement would seem to reside in th clarity of pattern of the time-embedded biological distances in the present study o Maya Indian dermatoglyphics. It is know that the three regions of Maya occupatio have been largely if not wholly separat since the Spanish Conquest over 4 cen turies ago. Beyond that, archeological an linguistic data (pp. 47–48) suggest a least as many more centuries of essentia separateness of these regions. Indeed som degree of archeological separation betwee the North and South Highlands may g back to the Pre-Classic horizon (200 B.C. 200 A.D.). It is quite likely, though cu rently undemonstrable, that the relationships between the South Highlands an the Lowlands go back about 1000 years.

Some of the reasons why dermatoglyph analysis seems able to bridge such tim intervals have already been stated by Cummins and Midlo ('43, p. 254). Other tha being genetically complex, dermatoglyph traits appear to be nonadaptive, or at lea nearly so. Moreover they are free fro postnatal modifications. Finally, howev arbitrary the methods of formulating de

al ridge configurations may be, these
rmulations can be applied by different
bservers with a quite high degree of ob-
ctivity. Given these desirata, it only re-
ained to apply dermatoglyphic methods
reasonably adequate samples of popula-
ons presenting the clear-cut problems of
ological distance perceived by Stewart.
he results would appear to be almost as
ear-cut as the problems, suggesting that
e materials and methods were well
atched to the dimensions of the problems
emselves.

CONCLUSIONS

Analysis of the index of finger pattern
tensity and the palmar main-line index
dicates a biological division between the
orth Highland Maya north of the Chu-
umatanes escarpment and the Maya
om the South Guatemalan Highlands and
e Yucatan Lowlands. This southern es-
rpment of the Chuchumatanes Massif
so serves as a partial barrier to flow of
nguage, and archeological and modern
ltures. The South Highland region is
presented by two Cakchiquel and one
uiché sample from the Lake Atitlán Ba-
n, and these appear to form a single
ological population. The biological dis-
nce between the two Cakchiquel samples
no closer than between either one and
e Quiché sample. Of the three, the Cak-
iquel sample from Patzún, east of Lake
itlán, is the most distinctive and these
rticular distinctions place it in quite
ose relationship with the Lowland Yuca-
c Maya. Taken together, the Atitlán Ba-
n samples sufficiently approximate the
wland Maya in a dermatoglyphic sense
suggest strongly that they belong to the
me close grouping of populations. The
rmatoglyphic ties of the North Highland
aya of the Guatemala-Chiapas uplands
pear to be with the various non-Maya
dians of Mexico further to the north.

The clarity of pattern of biological dis-
nces between the community and re-
onal samples amply demonstrates the
levance of established dermatoglyphic
ethods to the study of actual popula-
onal units. Supported by cultural and
guistic data, these methods appear cap-
le of penetrating considerable spans of
me in discerning biological relationships.
Since dermatoglyphic traits are polygenically controlled, putatively nonadaptive, and undergo no postnatal modifications they have distinct methodological advantages over either anthropometry or serology in clarifying the older and more basic relationships between human populations.

ACKNOWLEDGMENTS

In carrying out this study I have been continually aware of my very considerable professional and personal debt to Dr. Harold Cummins, world leader in the field of dermatoglyphics. What I know about this field has been largely derived from his writings. In the present study, the pattern formulations he made on part of the samples permitted me a most adequate check on my own techniques. To Dr. T. Dale Stewart I owe thanks for collecting the palm and finger prints and for having the foresight to note all the essential data on provenience for each subject. I am additionally grateful for the useful discussions we had during the course of the study. Two more of my colleagues have helped me tremendously, Dr. Gordon Gibson has most ably advised me on statistical procedures, and Dr. Stephan Borhegyi has given me the benefit of his knowledge of Highland Maya archeology.

LITERATURE CITED

Aguirre, F., O. B. Tandon and N. S. Scrimshaw 1953 Distribution of blood groups in Guatemala. Records of the Genetic Society of America, No. 22, p. 63.

Arteaga, C., M. Salazar-Mallen, E. L. Ugalde and A. Velez-Orosco 1952 Blood agglutinogens of the Mexicans. Ann. Eugenics, *16:* 351–358.

Birdsell, J. B. 1952 On various levels of objectivity in genetical anthropology. Am. J. Phys. Anthrop., *10:* 355–362.

Borhegyi, S. F. 1956 The development of folk and complex cultures in the Southern Maya area. Amer. Antiq., *22:* 343–356.

Cummins, H. 1932 Dermatoglyphics in the Indians of Southern Mexico and Central America. Middle Amer. Res. Ser., *4:* 183–208.

——— 1936 A retabulation of the palmar dermatoglyphics in Wilder's collection of Mayas, with a note on the Wilder collection of dermatoglyphics. Ibid., *7:* 197–202.

Cummins, H., and C. Midlo 1943 Fingerprints, Palms and Soles. The Blakiston Co., Phila.

Cummins, H., and M. Steggerda 1936 Fingerprints in Maya Indians. Middle Amer. Res. Ser., *7:* 103–126.

Furuhata, T. 1927 The difference of the index of fingerprints according to race. Japan. Med. World, *7:* 162–164.

Geipel, P. 1955 Tastleislenbefund bei Yupa-Indianern West-Venezuelas. Zeit. Morph Anthrop., *47:* 127–146.

Goodner, J. 1930 Incidence of blood groups among the Maya Indians of Yucatán. J. Immunol., *18:* 433.

Henckel, K. O. 1933 Sobre la disposición de las crestas papilares de las falangitas en los indígenas de la provincia de Cautín. Bol. Soc. Biol., Concepción, 7.

Keith, H. H. 1924 Racial differences in the papillary lines of the palm. Am. J. Phys. Anthrop., *7:* 165–206.

Lasker, G. W. 1954 Human evolution in contemporary communities. S. W. J. Anthrop., *10:* 353–365.

Leche, S. M. 1933 Dermatoglyphics and functional lateral dominance in Mexican Indians (Mayas and Tarahumares). Middle Amer. Pamphlets, No. 2 of Middle Amer. Res. Ser., *5:* 29–42.

——— 1936 Dermatoglyphics and functional lateral dominance in Mexican Indians: IV. Chamulas. Anthropometry of the Chamulas. Ibid., *7:* 287–312.

Leche, S. M., H. N. Gould and D. Tharp 1944 Dermatoglyphics and functional lateral dominance in Mexican Indians. V. The Zinancantecs, Huixtecs, Amatenangos and Finca Tzeltals. Middle Amer. Res. Records, *1:* 21–84.

Matson, G. A., and J. Swanson 1959 Distribution of hereditary blood antigens among the Maya and non-Maya Indians in Mexico and Guatemala. Am. J. Phys. Anthrop., *17:* 49–74.

McBryde, F. S. 1945 Cultural and historical geography of Southwest Guatemala. Inst. of Soc. Anthrop., Pub. No. 4 (Smithsonian Institution), 184 pp.

McQuown, N. 1956 The classification of th
Mayan languages. Internat. J. Amer. Ling
22: 191–195.

Newman, M. T. 1936 A comparative study
fingerprints and toe prints. Human Biol.,
531–552.

——— (Ms.) Palm and fingerprints of Qu
chua Indians from the North Central Peruvia
Sierra.

Rife, D. C. 1953 Fingerprints as criteria
ethnic relationship. Am. J. Human Genetic
5: 389–399.

——— 1954 Dermatoglyphics as ethnic cr
teria. Am. J. Human Genetics, *6:* 319–327.

Rife, D. W. 1932 I gruppi sanguigni fra g
Indiani di alcune region dell' America Central
J. Immunol., *22:* 207.

Siverts, H. 1958 Social and cultural chang
in a Tzeltal (Mayan) Municipio, Chiapa
Mexico. Proc. 32nd International Congr. Ame
icanists (Copenhagen), pp. 177–189.

Steggerda, I. D., M. Steggerda and M. S. La
1936 A racial study of palmar dermatoglyp
ics with special reference to the Maya India
of Yucatan. Middle Amer. Res. Ser., *7:* 12
194.

Swadesh, M. 1958 Some new glottochronolog
dates for Amerindian linguistic groups. Pr
32nd International Congr. of Americanis
(Copenhagen), pp. 671–674.

Stewart, T. D. 1947 Anthropometry of t
highland Maya. Carnegie Inst. of Wash. Ye
Book for 1946–47, pp. 195–197.

Wolfe, R. I. 1950 The phylogeny of digit
patterns in man and its bearing on rac
affinities: A study in human ecology. Hum
Biol., *22:* 34–64.

n Archaeological Scaphocephal from California

WILLIAM D. HOHENTHAL AND SHEILAGH THOMPSON BROOKS
Department of Anthropology, San Francisco State College and
Department of Physiology, University of California

Archaeological background

The scaphocephalic specimen described this paper was uncovered in the Fall 1957 by an archaeological field crew om San Francisco State College in the esence of one of the authors. The lo- le is a large aboriginal occupation site iown as 4-Ala-328, Newark Site[1] on the utheast shore of San Francisco Bay.

In outline the site is a large ovoid ound, approximately 350 feet north- uth axis and 250 feet east-west diam- er, with a depth of some 13 feet near e center, the cross-section being typi- lly lenticular. The mound rises from a t alluvial plain, 6 feet above sea-level, an elevation of 15½ feet above sea- vel at its highest point. The site is on e Patterson Ranch, three miles due uth of the small town of Alvarado.[2]

Including earlier excavation at the ewark site in 1935, extensive annual ork at the mound from 1949 to 1958 s resulted in some 300 burials and over 000 artifacts, with about 25% of the idden having been explored. Osteolog- al remains and cultural evidence leave no ubt that the inhabitants were Amerindi- s. A mound recognized as an ancient dian habitation appears on an early ap (1873) of San Francisco Bay at the pproximate location as the one under scussion, but as there are actually two ounds here (4-Ala-328 and 4-Ala-329), e cannot be sure to which mound the ap precisely refers. The historic ab- igines of this region were called gener- ly “Costeño” (coast-dwellers) by the rly Spanish and later Mexican settlers; is term has been anglicized to “Costa- an” and so appears in anthropological d historical literature.

Archaeologists distinguish for Central lifornia three cultural horizons, termed *Early,* ending about 4,000 years BP; *Middle,* beginning about 3,500 years BP; and *Late,* beginning about 1,200 years BP and lasting until historic times, or contact with Europeans.[3] In certain sites there may be considerable over-lap of the three horizons.

From archaeological investigations by the University of California and San Francisco State College, it appears that the San Francisco Bay region was occupied by Middle Horizon hunters and shellfish gatherers by 3,500 years BP. Cultural distinctions in the Newark site under consideration are Earlier Middle, Later Middle, and Late Horizons. Radiocarbon dates (sample C-690) have been obtained from wood charcoal from the Later Middle Horizon level[4] (table 1).

The scaphocephalic individual (burial no. 248) considered in this paper is from the Later Middle Horizon. Any precise archaeological conclusions for the mound as a whole must await detailed analysis of field data by the archaeologist in charge, Dr. Adán E. Treganza,[5] as work at the site still continues.

---

[1] *4* designates California, *Ala* represents Alameda County, and 328 is the site number registered with the California Archaeological Survey, University of California (Berkeley).

[2] Grid coordinates 89050 rt/1643150 up, Hayward Quadrangle. War Department, Corps of Engineers, U. S. Army. Grid zone “G”, 1942.

[3] B. P. signifies “Before Present.”

[4] Libby, W. W. 1954 Chicago radiocarbon dates. IV. Science, *119:* 135–140. *See also* Heizer, R. F. 1958 Reports of the University of California Archaeological Survey, No. 44, issued October 10. (The notation “B53” indicates that the carbon-14 sample was taken before 1953.)

[5] Continued excavation of the Newark site for a number of seasons to come is planned by Dr. Adán E. Treganza, Chairman of the Department of Anthropology, San Francisco State College. The mound serves to train students in archaeological field techniques.

TABLE 1

	BP date	1 γ Range BP	B.C.–A.D. date	1 γ Range B.C.–A.D.
	2,588 B53 200	2,788–2,388 B53	635 B.C. 200	835 B.C.–435 B.C.
	2,090 B53 220	2,310–1,870 B53	137 B.C. 220	357 B.C.– 83 A.D.
Av.	2,339 B53 150	2,489–2,189 B53	386 B.C. 150	536 B.C.–236 B.C.

Ecological considerations

Composition of the midden is like that of most Amerindian sites bordering San Francisco Bay, except for the relatively low content of shell from soft-shelled clams (*Macoma masuta*). Commonest of all shell is oyster (*Ostrea lurida*).

The mound lies on the edge of a marshy slough, of which the present Coyote Hill Slough is a remnant. The soil is black, compacted with considerable fragmented shell, animal bone, burned and decayed vegetal matter, and is very moist until exposed to the air, whereupon it dries to a greyish black hue.

As the mound is usually flooded at the base each winter, owing to heavy rains, osteological material does not bear up very well and many burials are in poor condition. Another destructive factor is tunneling by burrowing animals such as moles and voles, gophers and badgers, which disturb the skeletal remains. In addition, the mound surface has been altered to a depth of 18 inches by extensive cultivation.

The old sloughs and tidal marsh lands have been reclaimed since 1917 by a system of levees for the development of farm lands and salt evaporation works. Thus San Francisco Bay, once immediately adjacent to the site, has been removed about three miles to the northwest.

About a half-mile to the west lie the Coyote Hills, averaging 200 feet in elevation, and extending three miles on a northwest-southeast axis; the Hills are approximately one-half mile in width. Six miles to the east lies the base of the Coast Range foothills.

There are still some stands of valley oaks (*Quercus lobata*) here, and in the nearby foothills several species of coastal live oak (*Q. agrifolia* and *Q. wislizenii*) and buckeye (*Aesculus californica*) are to be found. These trees were all utilized as a source of foodstuff by the historic aborigines and, we may presume, by th prehistoric ones as well. Willows and tul rushes grew along watercourses an sloughs, providing the inhabitants wit the raw materials for both housing an watercraft.

Items in the diet of the native popul tion are reflected by the importance o various kinds of shell, remnants of crust ceans and fishes, and bird and anim bone in the midden. Aside from the ver common oyster and soft-shelled clam abalone (*Haliotis*), mussels (*Mytilu edulis*), and marsh snails (*Cerethidi californica*) were abundant, to name bu a few of the many molluscs and gastro pods utilized by the local Amerinds. Fishe and waterfowl were also of great impo tance.

Mammals frequently eaten or hunte included deer (*Odocoileus*), antelope (*An tilocapra americana*), wapiti (*Cervus* sea-otter (*Enhydra*), river otter (*Lutra* raccoon (*Procyon lotor*), badger (*Ta idea*), coyote (*Canis latrans*), and occ sionally seal (*Phoca*) and sea-lion (*Za ophus* or *Calorhinus*).

Although in this site precise botanic evidence is lacking for grains and seed fruits and wild roots, tubers, and green we may deduce their ingestion by th aborigines of the Newark mound throug the presence of lithic and basketry art facts for processing hard seeds, nuts, an legumes. Furthermore, we know throug ethnographic evidence that great relianc was placed on such vegetal foodstuffs b California Indians, and that in fact suc formed a large proportion of the die From this brief review of available food there is no reason to believe that the die of these aborigines was sub-optimum i either quantity or in nutritive quality.

Description of the cranium

Artificial head deformation does not o cur in skeletal collections from archae gical sites of the San Francisco Bay gion, nor for that matter, is it found in e rest of California. Accordingly, it is ost probable that the skull belonging to ırial no. 248 is an example of marked aphocephaly.

We have compared its cranial measureents with those of the scaphocephalic ull described by Eiseley and Asling 44), also an archaeological specimen, esumably Amerind, and in this case om Kansas.

The California cranium has an even eater glabella-occipital length (203 m) than the Kansas skull (194 mm), though the greatest cranial breadth, ken on the temporals, being 120 mm is ly slightly narrower than that of the ansas specimen (121 mm). The resultıt cranial index of 59.2 is three points low the Kansas equivalent (62.3). The anial capacity of both specimens is well th the range of present-day *Homo piens*, the Kansas skull being 1306 cm^3 d the California cranium being 1432 n^3. As a whole, the remainder of the anial measurements are not extreme, d fall within the range of pre-Columan Indian groups (Gifford, '26).

The only measurements affected by the aphocephalic condition are those length d breadth measurements which relate the vault. In the table where vault, cial, mandibular, and post-cranial measements and indices are listed, those alred by scaphocephaly have been marked th an asterisk, following the usage of seley and Asling.

Although the post-cranial skeleton is t discussed in this paper, briefly it may stated that, while poorly preserved chaeologically, it did not seem to be ibly abnormal. The stature estimates re derived from the maximum lengths the humerus, radius, and ulna, using otter and Gleser's ('58) formulae. The ight of about 170 cm seems to be avge for a California Indian, and appartly shows no effect of any endocrine order.

Eiseley and Asling consider all the exnal aspects of their specimen in great ail, and for the sake of comparison we low their procedure. Facially, the Calrnia skull is remarkable for the very wide suborbital fossae. The teeth are worn well through the dentine and about half way through the tooth structure proper, which is not a common observance amongst California Indians for an individual in his early thirties. There is one

TABLE 2

Measurements and indices of burial no. 248, ALA 328

Cranial measurements	
Glabello-occipital length[1]	203 mm
Maximum width[1]	120 mm
Basion-Bregma height	140 mm
Auricular height	114 mm
Minimum frontal diameter[1]	89 mm
Maximum frontal diameter[1] (width at stephanion)	76 mm
Maximum bizygomatic diameter	135 mm
Menton-Nasion height	113 mm
Prosthion-nasion height	72 mm
Basion-nasion	111 mm
Basion-prosthion	106 mm
Nasal height	51 mm
Nasal breadth	25 mm
Orbits-height, right	34 mm
Orbits-height, left	33 mm
Orbits-breadth, right	—
Orbits-breadth, left	42 mm
Interorbital breadth	20 mm
Biorbital breadth	—
Foramen magnum, length	38 mm
Foramen magnum, breadth	30 mm
Nasion-opisthion arc[1]	392 mm
Nasion-Bregma Arc[1]	130 mm
Bregma-Lambda Arc[1]	125 mm
Lambda-Basion Arc[1]	137 mm
Arc transverse	293 mm
Total facial angle	83
Mid-facial angle	84
Cranial indices	
Cranial capacity (basion-bregma height)	1431.71 cm^3
Cranial capacity (auricular height)	1372.96 cm^3
Cranial index[1]	59.2
Height-length index[1]	69.0
Height-breadth index[1] (basion bregma)	116.7
Height-breadth index[1] (auricular height)	95.0
Fronto-parietal index[1]	74.1
Auricular height-length index[1]	56.2
Cranial module (basion bregma)	154.3
Cranial module (auricular height)	145.7
Facial index	84.4
Upper facial index	53.7
Cranio-facial index[1]	111.8
Gnathic index	95.5
Nasal index	49.0
Orbital index, right	—
Orbital index, left	78.5

---

[1] Measurements affected by the scaphocephalic condition of the cranium.

TABLE 3

Mandibular measurements	
Condylo-symphyseal length	111 mm
Bicondylar width	122 mm
Height of aymphysis	—
Bigonial diameter	97 mm
Height of ascending ramus	64 mm
Minimum breadth of ascending ramus	38 mm
Mean angle of lower jaw	116
Mandibular indices	
Mandibular index	91.0
Zygo-gonial index	72.4
Fronto-gonial index	109.0
Post-cranial measurements	
Humerus, right, maximum length	326 mm
Humerus, right, maximum head diameter	50 mm
Humerus, right, minimum shaft circumference	59 mm
Radius, right, maximum length	250 mm
Ulna, right, maximum length	268 mm
Post-cranial indices	
Robusticity index, humerus	65.2
Humero-radial index	76.7
Stature, humerus[1]	170.6 cm
Stature, radius[1]	170.5 cm
Stature, ulna[1]	167.7 cm
Stature, humerus and ulna[1]	171.0 cm
Stature, humerus and radius[1]	171.0 cm

[1] Utilizing Trotter and Gleser's ('58) formulae for Mongoloids.

large abcess in the maxilla where the right M-1 has been lost. The mandibular third molars appear to have been erupted and lost during life, and the alveolar tissue absorbed. There is no indication of an eruption of the upper third molars. The left mandibular condyle has a wide flattened facet which fits a similarly large and flattened area in the corresponding glenoid fossa.

One major difference between the Kansas and the California crania should be noted: Eiseley and Asling remark that the mastoid processes of their specimen are the "shortest and most blunt the writers have ever seen in an adult human skull" ('44, p. 244). On this basis they propose, in the etiological section of their paper, that short, blunt mastoids may characterize the scaphocephalic skull, thus possibly being part of the syndrome. However, the California cranium was recently inspected by Professor Asling, who agreed verbally with the present writers that the mastoids of this specimen are of the long and heavy type characteristic o the normal adult male. It is possible, therefore, that the mastoids of the Kansas skul represent an individual peculiarity, an have nothing to do with its scaphocephalic condition.

Both the coronal and occipital suture of the California skull are pronouncedl serrated. Near asterion there occur bilaterally several small Wormian bone Larger Wormian bones near the tempora suture are not bilaterally symmetrica Where the sagittal suture has prematurel closed there is a palpable slight hum although this is not visible in the plate (q. v.).

Only one parietal foramen is presen located near the midline, which featu is not uncommon to crania from the Sa Francisco Bay area. There is an irregula unilateral depression between the for men and lambda at obelion, perhaps similar to the one described by Eiseley an Asling, but in contrast, no bosses exist o either side of the depression such as the discuss for the Kansas specimen.

The entire occipital region of the Ca fornia cranium protrudes in a bun shap The muscular markings at the nuch lines are not heavy, although the media occipital fossa is fairly deep with a sha muscular attachment. Other indicatio of muscularity are the strong tempo muscle lines, the prominent glabella, a the median supraorbital crests.

The nasal bones are high, with a stro concavo-convex bridge as seen in profi The mylo-hyoid ridge of the mandible very pronounced, as are the pterygoid tachments, giving the body of the ho zontal ramus an appearance of streng and heaviness. The chin is bilateral a protruding, completing the overall pictu of masculinity and muscularity present in the facial features of this cranium.

Endocranially, the California skull do not seem to differ from the several oth California Indian crania with which has been carefully compared. None the vascular markings is remarkably dee nor is there any unusual pitting.

The occipital region follows the sa pattern as that of other California Indi skulls used for comparison. The o feature which is different is that in e of the sagittal suture there is a very ght depression which runs from bregma lambda. Both the coronal and occipital ures are partially closed but are still ible endocranially.

The California skull does not follow the othetical pattern suggested by Eiseley l Asling of "deeply channeled cranial uses, the peculiar form of the mastoids, l the two curious bosses near obelion" 4, p. 254). Instead, the California spe- ien appears endocranially normal when mpared with other Amerindian crania, ept for the completely closed sagittal ure and the slight depression in the lline. Endocranially, the only char- eristics which may have direct bearing the closure of the sagittal suture is irregular, unilateral depression at lion, and the lack of parietal bosses. should be noted in relation to this er point that the measurement of max- im breadth had to be taken on the nporals, rather than at the usual loca- n of the parietals.

Martin ('28) defined scaphocephaly as ng caused by premature suture obliter- on brought about by congestion and in- nmation (hypervascularization). Such ostoses hinder the growth of the brain, vever, only in the vertical direction of effaced suture, and therefore, the in presses antero-posteriorly where no nteracting resistance is encountered, s resulting in a compensatory expan- n. Basically, this definition is still in eement with recent general texts such Potter ('52) and Arey ('54). Martin further described the scaphocephalic nia anthropometrically ('28, pp. 827–):

> Undeniably, the breadth development the skull is arrested owing to early ure of the sagittal suture, and so de- ops the scaphocephal or 'skiff-skull,' ch, by its abnormally narrow breadth its considerably extreme length, ap- rs to be inordinately dolichocephalic th an index of between 60 and 70 but as low as 55).
>
> Because of the strong keel-shaped re- tion of the skull vault toward the vn (length-height index is about 6, with considerable individual fluctuation), and owing to the great absolute length of the vertical (or coronal) portion of the skull, this upward-thrusting, extremely narrow, and lengthened frontal bone in the sagittal plane, and with the occipitum being drawn strongly downward and to the rear, easily distinguishes itself, however, from the normal dolichocephal.
>
> "Consequently, the ridge- or keel-shaped elevation of the crown (*culmen cuneiforme*), owing to compression and because of the angular position of the parietals, originates, as already intimated, for the most part in the foetal inception of the *regio obelica* and is completed through obliteration of the sagittal suture during the first 10 years of life.
>
> "Frequently it so happens that instead of the embryonic sagittal frontal suture being drawn to and above the frontal bone to the crest of the skull, or *carina*, it may descend as low as glabella. Scaphocephals are found not only amongst European racial varieties, but also amongst Egyptians, Negroes, and other human groups as well." (Translated from the German by W. D. H.)

The etiology of the Kansas scaphocephalic skull was thoroughly discussed by Eiseley and Asling in their cited paper. In order to determine if new information had come to light since 1944, reference was made both to Potter ('52) and Arey ('54) for their descriptions of the cause of scaphocephaly which, as stated above, did not vary much from Martin's classic definition. In fact, Hope, Spitz and Slade ('55, p. 186) in their paper on premature cranial synostosis 27 years later admit that "the factors incriminated in the possible etiology of craniostenosis are many, but none has stood the test of time and investigation. We know of no specific infection or metabolic defect which might cause it. Repeated study of the bone involved in the premature synostosis has demonstrated no abnormality under gross or microscopic examination." The same authors also have found that as long as the skull can continue to expand, utilizing sutures not involved in the synostosis, the only indication of the disorder will be excessive elongation and scaphoid shape of the skull. When the compensatory expansion cannot take place, and intracranial pressure is created, then clinical manifestations such as mental retardation and convulsive seizures may develop.

An interesting aspect of the problem is that in the cases of children with a lack of thyroid output, care must be exercised in giving such patients supplementary thyroid extract so that premature closure of the cranial sutures does not take place.[6]

With relation to the possibility of a glandular imbalance, lateral x-rays of the cranium were taken by Dr. Howard Wright of the University of California's Department of Anatomy.[7] Thickness of the cranial bone is normal, as is the configuration of the endocranial surfaces. There may be some excavation of the floor of the pituitary fossa, but owing to the poor preservation of the cranium no positive conclusions can be drawn.

The only unusual feature is the size of the sella turcica, which measures 18 mm in antero-posterior diameter, that being much larger than the range of 8 to 13 mm cited in Brailsford ('53). Carey ('27), in an article describing various cranial anomalies, has referred to an enlargement of the sella turcica in some of the cases of scaphocephaly investigated by him.

Care must be taken not to confuse scaphocephaly, as defined by Martin ('28) and also by various pathologists (Carey, '27; Potter, '52; Arey, '54), with scaphoid skulls, which are gable-shaped and noteworthy for the longitudinal keel along the line of the sagittal suture. Scaphoid skulls are not necessarily hyperdolichocephalic, do not show premature synostosis of the sagittal suture, and may be considered to be quite normal. In this connection we may note certain terminological lapses in the anthropometrical literature, for instance, Hooton's *Indians of Pecos Pueblo*,[8] where confusion seems to exist regarding scaphoid and scaphocephalic crania.

CONCLUSIONS

From a comparison of the Kansas and California crania, it is probable that scaphocephaly, while manifesting grossly similar traits, does vary in particulars, pointed out in this paper.

Therefore, we suggest that scaphocep aly need not always follow the same pa tern of minor anomalies or hypoplasi postulated by Eiseley and Asling. Ho ever, more such investigations are nece sary before any generalizations can made regarding expected osteologic causes and effects.

It is suggested that both the archa ologist and the physical anthropologi become aware of this sort of anomal More such synostosed crania, not only the scaphocephalic type, but all tho caused by the premature closure of oth sutures, when reported, may broaden t clinical picture. The time depth and quences involved in archaeological spe mens can sometimes shed light on gene and population distributions of speci anomalous characters. The medical lit ature, used here as source material, h as its function the publication of descr tions of such anomalies or hypoplasias aid in clinical diagnoses and treatme The purpose of this paper and any oth describing pathologies or physical oddit in archaeological populations could used to clarify genetic and demograp studies of ancient peoples. Osteological little is found referent to the diseases whi plague human beings, and even with spect to those which do attack bone, f diseases are accepted as being recogn able in the pathological specimens served in archaeological collections. It all the more important, then, to prese and record in detail those anomal which are known medically and wh can be recognized osteologically.

LITERATURE CITED

Arey, L. B. 1954 Developmental Anatomy, ed. W. B. Saunders Co., Philadelphia London.

---

[6] Dr. Ian W. Monie, of the Department Anatomy, University of California Medical Cen in a verbal communication to S.T.B.

[7] The x-rays were taken with equipment vided through the courtesy of Dr. C. W. As Chairman, Department of Anatomy, Unive of California.

[8] Hooton, 1930, p. 323 and plate X-19 (men no. 59, 985); and p. 326 and plate (specimen no. 60, 225, erroneously listed in publication as no. 60, 255).

ailsford, J. F. 1953 The Radiology of Bones and Joints, 5th ed. J. and A. Churchill, Ltd., London.

rey, E. J. 1927 Human anomalies, practical Roentgenographic studies. Study I; abnormal crania—hydrocephalic, achondroplastic, oxycephalic and acromegalic. Wisconsin Med. J., August, pp. 1–12.

seley, L. C., and C. W. Asling 1944 An extreme case of scaphocephaly from a Mound Burial near Troy, Kansas. Trans. Kansas Acad. Sci., *47:* 241–255.

fford, E. W. 1926 California Anthropometry. Univ. Calif. Publ. in Amer. Archaeol. and Ethnol., *22:* 217–390.

eizer, R. F. 1958 Reports of the Unviersity of California Archaeological Survey, no. 44. Issued October 10, 1958, Berkeley, California.

Hope, J. W., E. B. Spitz and H. W. Slade 1955 The early recognition of premature cranial synostosis. Radiology, *65:* 183–193.

Hooton, E. A. 1930 The Indians of Pecos Pueblo: A Study of their Skeletal Remains. Published for the Department of Archaeology, Phillips Academy, Andover, Massachusetts, by the Yale University Press. New Haven, Conn.

Libby, W. F. 1954 Chicago radiocarbon dates. IV. Science, *119:* 135–140.

Martin, R. 1928 Lehrbuch der Anthropologie, 2nd ed., vol. 2. Gustav Fischer, Jena.

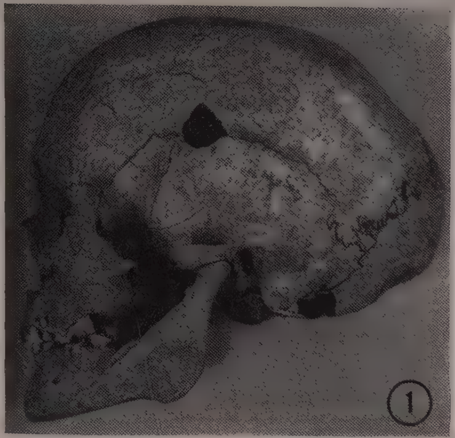
Potter, E. L. 1952 Pathology of the Fetus and the Newborn. The Year Book Publishers, Inc., Chicago, Ill.

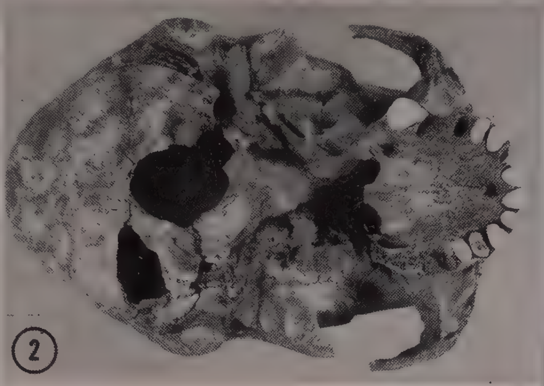
Trotter, M., and G. C. Gleser 1958 A re-evaluation of estimation of stature based on measurements of stature taken during life and of long bones after death. Amer. J. Phys. Anthrop., *16:* 79–123.

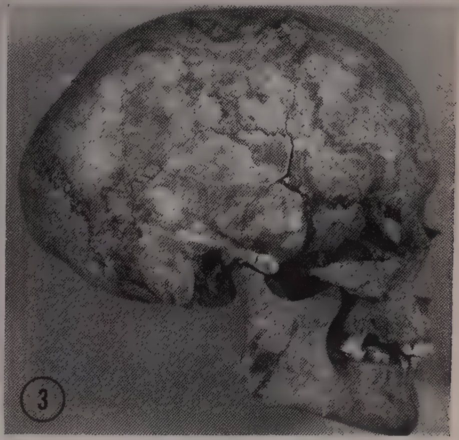
PLATE 1

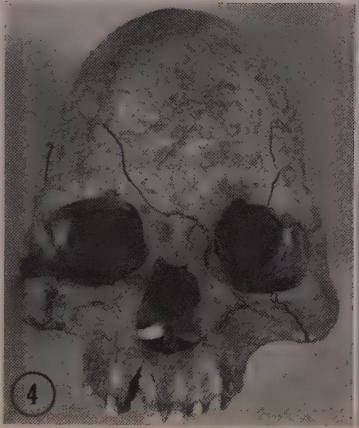
EXPLANATION OF FIGURES

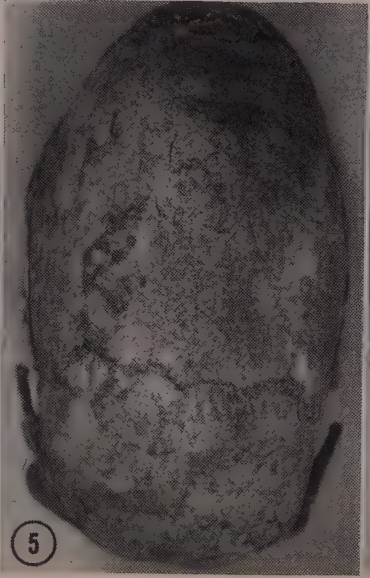
1 Norma lateralis, left, with mandible.
2 Norma basalis.
3 Norma lateralis, right, with mandible.
4 Norma frontalis, without mandible.
5 Norma verticalis.
6 Norma frontalis, with mandible.
7 Norma occipitalis.

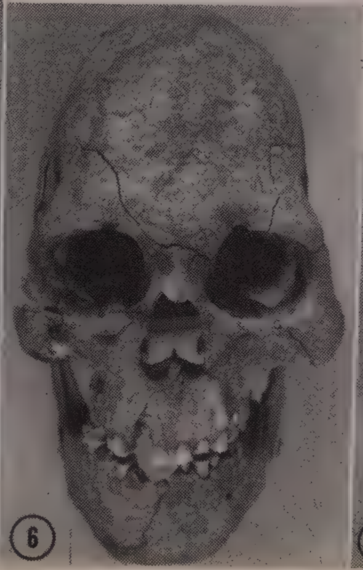

①

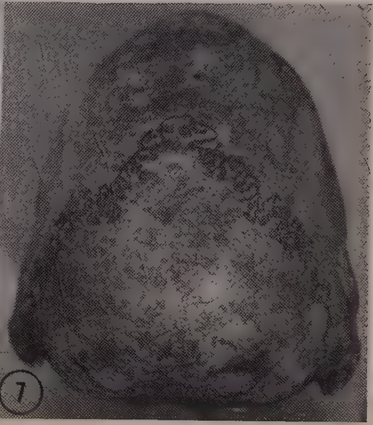

②


③


④


⑤


⑥


⑦

BRIEF COMMUNICATIONS

istology and Cytochemistry of Human Skin

XI. THE NERVES AROUND THE XILLARY APOCRINE GLANDS[1]

WILLIAM MONTAGNA AND RICHARD A. ELLIS
Arnold Biological Laboratory, Brown University,
Providence 12, Rhode Island

Although most authors (Shelley and urley, '53; Montagna and Ellis, '58; erry et al., '55) have not found nerves ontaining cholinesterase around the apo- rine sweat glands of man, Rothman '54) and Aavik ('55) have reported and lustrated such nerves around the axillary pocrine sweat glands. We now find that e apocrine axillary glands of the negro re surrounded by nerves containing cho- nesterase, but those of caucasians are ot.

MATERIALS AND METHODS

Biopsy specimens of axillary skin from 2 young negro men, and an unspecified rger number of specimens from the axil- e of caucasian men and women of all ges were fixed in chilled, unbuffered, 0% neutral formalin for 4 hours. Frozen ctions, 25 to 50 μ thick were incubated ree hours at 37°C in the mixture of oelle and Friedenwald ('49) as modified y Gomori ('52) (see Montagna and Ellis, 7 for the technique). Specific cholin- sterase, as used in this paper denotes at enzyme which hydrolyzes acetylthio- oline iodide, and which is inhibited by e presence of 10^{-5} eserine in the incu- ating mixture; pseudocholinesterase hy- rolyzes butyrylthiocholine iodide as well acetylcholine and is only partially in- bited by eserine.

OBSERVATIONS

The apocrine glands in the 12 speci- ens of axillary skin from negroes were l surrounded by varying numbers of ecific cholinesterase-containing nerves, hich are thicker than the nerves that rround the eccrine sweat glands (figs. 1 d 2). Some of the apocrine tubules are ore richly supplied with cholinesterase-reactive nerves than others, but all of the segments of the same gland are surrounded by an approximately equal number of nerves. The eccrine glands in the specimens are surrounded by thin, strongly cholinesterase-reactive nerve fibers (Thies and Galente, '57; Montagna and Ellis, '58) which seem to form denser skeins than those around the eccrine glands of caucasians.

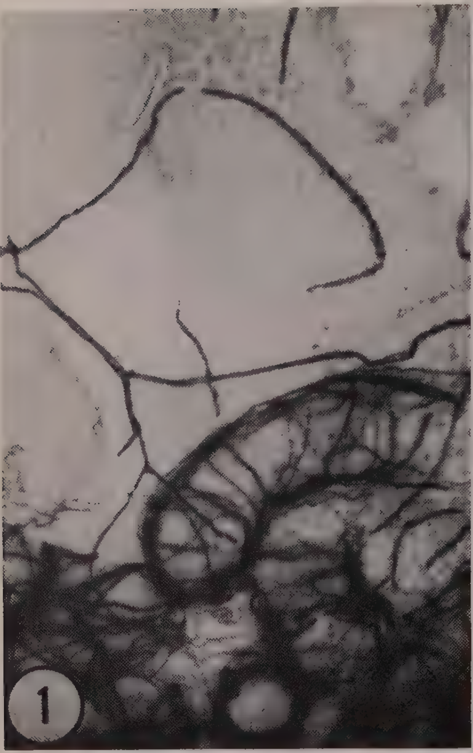
None of the apocrine glands in the many specimens of skin from caucasians shows a convincing association with cholinesterase-containing nerves. The occasional enzyme-reactive nerve one finds near some of the glands is probably not related to their innervation.

DISCUSSION

Since specific cholinesterase has been found in both motor and sensory nerve fibers (Beckett et al., '56), its presence cannot be considered to be a characteristic feature of cholinergic nerve fibers. Not enough is known about the role of this enzyme in the conduction of nerve impulses, and it would serve little purpose to discuss its possible significance. The important point here is that cholinesterase is present in the nerves around the apocrine glands of the negroes and not around those of caucasians. Since all of the specimens we have studied are from American negroes of unknown origin, it will be interesting to see what we will find when the glands of various ethnic groups have been studied. The presence of cholinesterase-containing nerves

---

[1] This work was supported by grants from the United States Public Health Service, RG-2125-(C9), National Science Foundation, G-4392, and the Colgate-Palmolive Company.



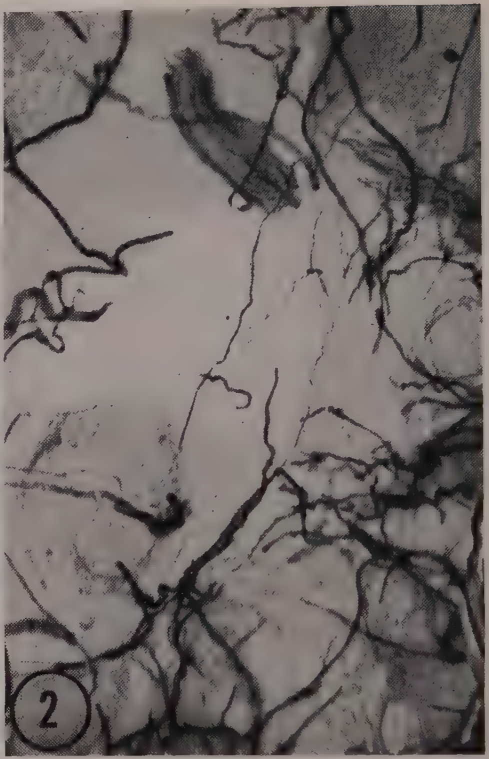


Fig. 1 Skin from the axilla of a negro showing, in the lower part of the figure, several segments of the secretory coil of an eccrine sweat gland, surrounded by numerous, specific cholinesterase-containing nerves. In the upper part of the figure a few cholinesterase-containing nerves surround a part of an apocrine gland. × 75.

Fig. 2 Skin from the axilla of a negro, showing numerous cholinesterase-containing nerves around the apocrine glands. These preparations were not counterstained and only the nerves can be seen. × 75.

around the apocrine glands, then, appears to be a characteristic feature of the axillary skin of the negro.

SUMMARY

Specimens of skin from the axilla of 12 American negroes all show the apocrine glands surrounded by nerves which contain cholinesterase. None of the glands from the axilla of caucasians shows such nerves.

LITERATURE CITED

Aavik, O. R. 1955 Cholinesterases in human skin. J. Inv. Derm., *24:* 103–106.

Beckett, E. B., G. H. Bourne and W. Montagna 1956 Histology and cytochemistry of human skin. The distribution of cholinesterase in the finger of the embryo and the adult. J. Physiol., *134:* 202–206.

Gomori, G. 1952 Microscopic Histochemistry. Principles and Practice. The University of Chicago Press, Chicago, Ill.

Koelle, G. B., and J. S. Friedenwald 1949 histochemical method for localizing cholin esterase activity. Proc. Soc. Exp. Biol. Med *70:* 617–622.

Montagna, W., and R. A. Ellis 1957 Histolog and cytochemistry of human skin. XII. Ch linesterases in the hair follicles of the scal J. Inv. Derm., *29:* 151–157.

Montagna, W., and R. A. Ellis 1958 L'histol gie et la cytologie de la peau humaine. XV Repartition et concentration des esterases ca boxyliques. Ann. d'Histochimie, *3:* 1–17.

Perry, E. T., H. J. Hurley, M. G. Gray and W. Shelley 1955 The adrenergic innervation the apocrine (ceruminous) gland of the h man ear canal. J. Inv. Derm., *25:* 219–221.

Rothman, S. 1954 Physiology and Bioche istry of the Skin. University of Chicago Pres Chicago, Ill.

Shelley, W. B., and H. J. Hurley 1953 T physiology of the human axillary apocri sweat gland. J. Inv. Derm., *20:* 285–295.

Thies, W., and L. F. Galente 1957 Zur his chemischen Darstellung der Cholinesteras im vegetativen Nervensystem der Haut. D Hautarzt, *8:* 69–75.

A Reevaluation of the Dental Status and Chronological Age of the Tepexpan Remains

MELVIN L. MOSS[1]
Department of Anatomy, College of Physicians and Surgeons, Columbia University, New York

In the course of a recent roentgenoraphic study of the cranial collections of he Museo Nacional in Mexico City an opportunity was provided to examine and ray the Tepexpan cranial remains, hanks to the courtesy of Prof. J. Romero, rof. A. Romano, Dr. S. Fastlicht and Sr. ario Pichardo del Barrio. These data, gether with other human comparative anial and dental material, suggest a ossible revision to the published stateents concerning both the dental status nd chronological age of this individual De Terra, Romero and Stewart, '49).

Dental status

New dental x-rays of the specimen, udy of other human skulls of established e and the professional experience of the uthor lead to the following corrections the description of Fastlicht ('49). A) There is no supernumerary tooth in e maxilla. On the contrary, this is ost probably the root of an extremely raded upper right central incisor tooth. nly dissection of the maxilla will definiely answer this question. It is possible at ante-mortem fracture hastened the s of crown height, although severe rasion by itself could account for such loss of substance (fig. 1). This diagsis has been independently confirmed a number of oral diagnosticians, both Mexico and in this country, who viewed e films without prior knowledge of their gin. (B) It is extremely likely that vere periodontoclasia ("pyorrhea") exed ante-mortem. A pattern of alveolar struction with a decreasing postero-anior gradient of severity has been rerted in the American Indian (Leigh, '25). It should be noted that this pattern varies somewhat from that currently observed in New York City (Miller and Seidler, '42; Bossert and Marks, '56). Figure 2 well illustrates this process in the mandible of a modern Mexican, 32 years of age (DA2-544, Museo Nacional). It is obvious that such total destruction of *alveolar* bone would leave no roentgenographic evidence of an alveolus in the residual *basal* bone of the jaws following dental exfoliation. It is likely that most of the marked dental loss of the Tepexpan specimen is due to periodontoclasia rather

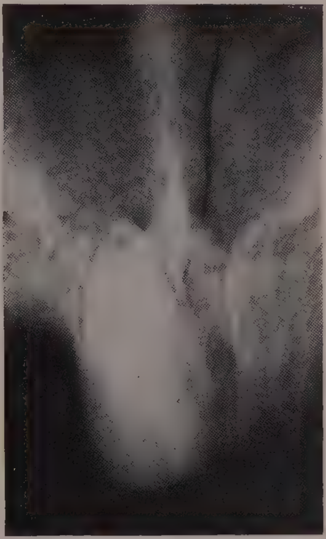


Fig. 1 Labio-lingual x-ray of the upper right maxillary tooth in the Tepexpan remains. The crown is abraded to the level of the alveolar ridge. The coronal area has a broad, flat, elliptical form when viewed in the specimen.

---

[1] Aided, in part, by grant B-965 (C-3), National Institutes of Health.

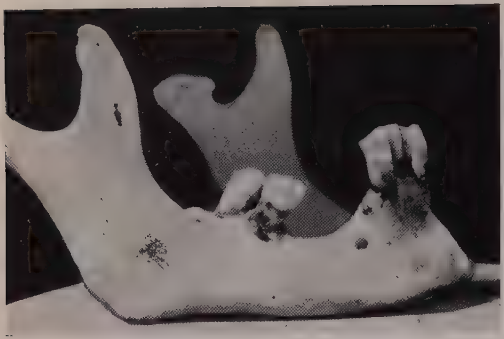


Fig. 2 Mandible of a 32-year-old modern Mexican (no. DA2–544, Museo Nacional). The process of periodontoclasia about these right molar teeth has destroyed most of the alveolar bone. Continuation of this process would have led to the loss of these teeth. This is presumably the manner in which most of the teeth were lost in the Tepexpan specimen. The left ramus has been retouched for contrast.

than to post-abrasive pulp exposure and subsequent apical infection.

Chronological age

(A) Figure 2 also illustrates that a dental loss, of possibly varying etiologies, virtually identical with that of the Tepaxpan specimen may occur in a relatively young adult. This is quite in accordance, again with our previous professional experiences with young Army recruits drawn from rural areas of the southern United States. (B) There is undoubted evidence of severe dental abrasion. However, even this degree of tooth crown loss is not inconsistent with relatively early age (cf. Leigh, '25; Mellquist and Sandberg, '39; Rabkin, '43). (C) The differential degree of radiopacity of the basal bone in the edentulous areas is inconclusive in the estimation of age. These differences reflect local differential thickness of both cortical plate bone and trabeculae rather than a differential reconstitution of empty dental alveoli, for the reasons stated above. (D) An estimate of chronological age (55–65) years has been made, based on cranial suture closure and on the data of Todd (table 3, p. 97, de Terra et al., '49). Current opinion on the use of sutural closure for aging has been succinctly summarized by Singer ('53) as a "hazardous and unreliable procedure." Based on these considerations it is permissible to revise the possible lower limit of estimated chronological age of the Tepexpan specimen to 25–30 years.

SUMMARY

The dental and chronological age status of the Tepexpan remains should be corrected in the following details: (1) supernumerary tooth is probably not present in the maxilla, (2) severe periodontoclasia was present and probably accounted for the majority of tooth loss, (3) the lower limit of the age estimate is 25–30 years.

LITERATURE CITED

Bossert, W. A., and H. H. Marks 1956 Prevalence and characteristics of Periodontal disease is 12,800 persons under periodic denta examination. J. Am. Dent. Assoc., 52: 429 436.
De Terra, H., J. Romero and T. D. Stewart 194 Tepexpan Man. Viking Fund Publ. in A throp., *11:* New York.
Fastlicht, S. 1949 The jaws of the Tepexpa skeleton. Appendix D. Ibid.
Leigh, R. W. 1925 Dental pathology of I dian tribes of varied environmental and foo conditions. Am. J. Phys. Anthrop., *8:* 179–19
Mellquist, C., and T. Sandberg 1939 Odont logical studies on about 1400 Mediaeval skul from Halland and Scania in Sweden and fro the Norse Colony in Greenland. Odontolo Tidsk., Suppl. 3B.
Miller, S. C., and B. B. Seidler 1942 Relati alveloclastic experience of the various teet J. Dent. Res., *21:* 365–371.
Rabkin, S. 1942 Dental conditions among pr historic Indians of Northern Alabama. Ibi *21:* 211–222.
Singer, R. 1953 Estimation of age from cr nial suture closure. J. Foren. Med., *1:* 52–5

ook Reviews

THE ECOLOGY OF HUMAN DISEASE. by Jacques M. May. Foreword by Felix Marti-Ibanez. 327 pp. $7.50. MD Publications, Inc. New York, N. Y. 1958.

This book is the first of a proposed three
olume work on the ecology of most of the
nportant human diseases. The present
olume only covers infectious disease—
nd not all of these—but other kinds of
sease such as degenerative and mental
ill be covered in future volumes. The
seases included in this volume are due
a variety of organisms ranging in size
om viruses to helminths, and there is
particular order to the coverage of
ese diseases. However, since each dis-
se or group of closely related diseases
s its own chapter and each chapter is
mplete in itself, the absence of order
es not detract from the value of the
ok. But the absence of order and the
phazard and, it seems to me, super-
ial character of the first four theoretical
apters make it appear that a prodigious
nount of work was done on each disease
parately and then the lot were thrown
gether into a book. Nevertheless, the
ok does contain a great deal of infor-
ation and will be a useful reference for
wide variety of scientists including, I
pe, physical anthropologists.

The usual arrangement for each chap-
r is first a definition of the disease and
outlining of the agent(s) and host(s),
en a tabulation of the geographical dis-
ibution of the disease which usually in-
udes one or more maps, and finally a
scussion of the factors which determine
is distribution. These factors are dis-
ssed under three major headings: inorganic, organic, and social and cultural, and it is in this portion of each chapter where some attempt is made to wrestle with the explanation of the distribution of the disease. To the reviewer these attempts were not too successful, and their failure appeared to be due for the most part to the nature of the data on the distribution of disease. The great majority of these data are government statistics on the numbers of cases and deaths for each disease within the country. Since countries or colonies are political units, they are seldom ecological units. Thus, it is difficult—if not impossible—to relate the distribution of disease as given by these figures to the inorganic, organic, and social and cultural factors or variables which the author himself maintains are crucial for understanding its distribution. The statement that there were 9668 cases of amebiasis in Ethiopia in 1954 is almost meaningless ecologically since this area undoubtedly contains many ecological niches both of man and the parasite. Much of the book is thus filled with data whose ecological significance is difficult to ascertain, and this makes the book appear to be a compilation of facts but not much of a contribution to the ecology of human disease—particularly when compared to recent British or Russian efforts (for a review, see J. R. Audy, Trans. Roy. Soc. Trop. Med. Hyg., 52: 308–328, 1958).

Frank B. Livingstone
Dept. of Anthropology
Univ. of Michigan

THE ABC BLOOD GROUPS. By A. E. Mourant, Ada C. Kopec and Kazimiera Domaniewsko-Sobczak. Pp. viii + 276, 6 maps. [Occasional Publication No. 13 of the Royal Anthropological Institute.] Charles C Thomas, Springfield, Ill. $8.75.

Twenty years have passed since William Boyd's original compilation of the ABO ood groups of the world, and a new sum- ary long has been overdue. Anthropolo- sts and human microevolutionists owe uch to Dr. A. E. Mourant and his co- ithors for having collected those data vering nearly two intervening decades id for having published them in a con- nient and useful form. It will be recalled ourant's 1954 book omitted the ABO ood groups in anticipation of the present iblication.

The bibliography contains 1056 refer- ces but the 240 pages of tables contain ta on nearly 4 times that number of ries since the authors have wisely pre- rved the entity of the smaller population its where feasible. The data are com- led in three tables which depend upon e distinctions between A_1 and A_2. Most ries make no such separation, and are und in table I (pp. 9–215). Populations which both A_1 and A_2 have been tested e arranged in table II (pp. 219–232). ble III contains series in which A_2 has en proved to be absent (pp. 235–240). ch table is geographically organized th the exception that a few well defined pulation groups, such as the Armenians sques, Eskimos, Jews, and the Lapps ho extend into a number of geograph- l or political areas) are listed in the be- nning in each table.

The first three maps detail the distribu- n of the genes A, B, and O in Europe. ice these are based upon the most mas- e data, they should be the most reveal- concerning the processes of human olution. They will certainly prove useful in many ways but through no fault of the authors, they suggest certain deficiencies from a microevolutionary point of view. With 5 per cent class intervals between isogenes, only the grosser features of the real distribution can be depicted. This scale, which no doubt is necessary in terms of sampling reliability, and perhaps other factors, may be too coarse to test adaptive processes as they may affect these genes on a microenvironmental basis. A more serious deficiency, which seems inherent in the bulk of serological investigations, involves the identity of the population actually sampled. When it is realized that microevolutionary studies in general will be conducted in one of two major dimensions, time or space, then specific kinds of information concerning the population tested is required for its future utility. In time-dimensioned designs a population must be specified so accurately that a future investigator, several decades later, will be able to retest the individuals again (or at least follow the pattern of survival and mortality among them)—or to retest their actual descendants. In a space-structured design, it is essential to specify the populations sampled, and the nature of the total populations they represent. In such cases, it is implicit that the factors, both cultural and environmental, which structure the populations must be detailed. Mourant has presented the existing serological data in two volumes and all anthropologists are deeply indebted to him. What is needed for the future is the systematic conversion of serological surveys into microevolutionary studies.

Joseph B. Birdsell
University of California
Los Angeles

he Age at Eruption of Third Permanent Molars in Iale East Africans

W. K. CHAGULA
Makerere College Medical School, Kampala, Uganda

Comparative racial studies on the ages eruption of permanent third molars ve been made by Suk ('19), Hellman 36), Steggerda and Hill ('42) and Shou- ('46). Suk working on the Zulus of uth Africa, and Carothers ('47) work- on Kenya tribes, have both studied the ıption of third molars in the Bantu, but ta is still lacking for the greater part of rica.

Suk found that, in general, third molars ıpted earlier in Zulus than in Euro- ans. Carothers' East African series of 0 school boys drawn from only a few nya tribes was small and, as he himself mitted, afforded only tentative con- ısions.

The main purpose of this study was to d to Carothers' data and so to provide ditional data for comparison with that ained from other African or Negroid ma- ial. It was also considered appropriate the same time, to determine the fre- ency of congenitally absent third molars d to evaluate the forensic significance of rd molars.

It was lastly felt that a brief and neral discussion of the various factors t influence the eruption of teeth might row some light on the possible reasons the racial differences in the ages at ption of third molars.

MATERIAL AND METHODS

The investigation was three-fold: oral living males for presence or absence of rd molars; skeletal for the absence of rd molars; and radiographic on all jaws h absent third molars.

Oral. In all 990 males ranging in age m 6 to 26 years were examined. Among se were male Makerere University Col- e students drawn from many parts of st Africa. The rest were male pupils attending schools in and around Kampala in Uganda. This series includes Bantu (the largest group), Nilotes and Nilo-Hamites. The tribal distribution of the subjects was as follows:

Bantu		Non-Bantu	
Ganda	470	Luo	39
Kikuyu	48	Etesot	17
Haya	18	Acholi	9
Chaga	35		
Other	288	Other	66
Total	859	Total	131

It may therefore be claimed that this series is fairly representative of the native population of East Africa.

The method employed was direct oral examination, a permanent third molar being recorded as present only when one or more cusps had cut the gum. Thus fractions of third molars erupted were counted as whole teeth erupted. No mirror was used during the examination. Each subject was asked to open his mouth as widely as possible and the teeth were then inspected in good natural light.

The ages of Makerere students were those recorded on their medical cards while in the case of the school boys the ages recorded in the school registers were taken as the true ages. Although no birth certificates nor registers were available to provide incontrovertible evidence of age, thorough questioning and the observer's personal experience made the age to within a year tolerably certain. All ages were recorded to the nearest year and they are probably more accurate before than after the age of 13. One source of inaccuracy is that after the age of 13, the keen competition for entry into secondary schools tempts boys to claim a lower age before admission. Also, in view of the fact that after the age of 13 judgment becomes more difficult for the observer, the results for the lower age groups are probably more reliable than those for the higher age groups. Generally speaking then, the findings in this investigation are less reliable than those of Clements et al. ('53) where the ages of the children were supported by birth certificates.

Skeletal. One hundred eighty-eight adult skulls were examined, the criterion for adulthood used being the union of the two bones at the occipito-sphenoid synchondrosis.

Radiographic. This was confined to those jaws in which no third molar was visible on examination of the 188 adult skulls. There were only 10 such jaws in the skulls examined.

RESULTS

The detailed data elicited after oral examination are set forth in table 1, where the 25 and 26-year age groups have been grouped together as "25 years and over." The percentage of males with all or no third molars erupted in each age group is shown in columns 4 and 5 respectively. For ease of analysis these results are graphically depicted in figure 1.

The results of the skeletal and radiographic examinations are shown in table 2, in which the combined incidence of absent third molars in upper and lower jaws is shown. It can be seen that the percentage of absent third molars is very low. Radiographic examination of the 10 jaws with absent third molars did not show any

TABLE 1

Numbers of third molars erupted in East African males at different ages

1 Age	2 No. of males examined	3 Males with stated number of third molars					4 Males with all third molars erupted	5 Males with no third molars erupted	6 Erupted third molars
		4	3	2	1	0			
years							%	%	%
25 and over	42	36	3	1	0	2	85.7	4.8	92.3
24	23	19	1	0	1	2	82.6	8.7	87.0
23	43	38	0	4	0	1	88.4	2.3	93.0
22	59	47	2	5	3	2	79.7	3.4	84.7
21	88	64	7	8	5	4	72.7	4.5	84.6
20	109	82	6	14	4	3	75.2	2.8	90.8
19	63	44	6	3	2	8	69.8	12.7	80.2
18	60	36	8	4	1	11	60.0	18.3	73.8
17	47	26	3	4	3	11	55.3	23.4	66.0
16	62	29	6	7	5	15	46.8	24.2	61.7
15	104	35	10	13	8	38	33.7	36.5	49.0
14	88	9	3	13	7	56	10.2	63.6	22.2
13	51	0	3	1	2	45	0	88.2	6.4
12	44	0	0	0	0	44	0	100	0
11	34	0	0	0	0	34	0	100	0
10	25	0	0	0	0	25	0	100	0
9	17	0	0	0	0	17	0	100	0
8	9	0	0	0	0	9	0	100	0
7	13	0	0	0	0	13	0	100	0
6	9	0	0	0	0	9	0	100	0

TABLE 2

Frequency of congenital absence of third molars in African males

Number of upper and lower jaws examined	Total number of M_3S that should be present	Total number of M_3S absent	Absent M_3S before x-ray	Absent M_3S after x-ray
			%	%
188	752	14	1.9	1.9

TABLE 3

A racial comparison of the frequency of congenitally absent mandibular third molars in males

Racial group and author	Number of jaws	Per cent absent M_3S
Chinese: Hellman ('28)	19	32
Eskimo: Goldstein ('32)	363	25.3
European: Hellman ('28)	61	20
American Indian: Hellman ('28)	55	13
American Negroes: Hellman ('28)	119	11
West African Negroes: Hellman ('28)	49	0
East Africans: Chagula	188	1.6

nerupted third molars and these must herefore be regarded as congenitally absent.

In table 3 a racial comparison of the ncidence of congenitally absent mandibular third molars in males is presented. n the adult male African skulls examined nly 1.6% of the mandibular third molars vere congenitally absent. This figure was btained by first of all multiplying 188 by . This gave the total number of mandibular third molars that should be present. here were only 6 mandibular third molars bsent out of the 376, and these expressed s a percentage give the figure 1.6. Again e very low incidence of congenitally absent third molars in East African males clearly shown.

DISCUSSION

Significance of the presence of all permanent third molars

After examining only 150 boys in a enya Secondary School, Carothers ('47) ade the following generalization: "If an frican has all his wisdoms he is unlikely be less than 17 years old." The data w available do not support this statement regarding the significance of the esence of all third molars in an individual. Within particular age groups, wever, one can roughly say what the obability would be of meeting a boy ith all his third molars erupted. Thus at e age of 14, inferring from table 1, the obability is 1 in 10; at 16 years 1 in 2; 18 years 3 in 5 while above 21 years is 4 in 5.

acial comparison of the ages at eruption of third permanent molars

The investigation shows that in some frican boys third molars begin erupting at the age of 13 and that by the age of 20, 75% have had all their third molars erupted (table 1). Suk ('19) found that in Philippinos and Zulus the third molar began erupting at the age of 13 and that most boys and girls had a full set of permanent teeth at the age of 20. The largest group in the East African series consisted of Bantu boys, hence this study corroborates Suk's findings among the Zulus of South Africa, concerning the ages at which third molars may appear in the Bantu and at which the permanent dentition is usually completed.

Suk found that in United States whites, the third molar was still absent in most cases at the age of 18. Shourie ('46) on the other hand, found that in East Indian boys third molars started to erupt as early as 13 years of age. This investigation, together with that of Suk and Shourie, shows that the eruption of third molars in Philippino, Zulu, East Indian and East African boys usually begins at a much earlier age than in European boys.

The forensic importance of third permanent molars

The presence or absence of third molars therefore contributes very little to the total dental and skeletal evidence necessary for determining age in Africans. This investigation shows that all a medical practitioner could infer about the age of an East African young man with all his third molars erupted is that the individual is at least 14 years old. Although there is no data for females, the main importance of this study is that it gives fairly accurate data for the first time in East Africa concerning the earliest age at which third molars begin to erupt in boys.

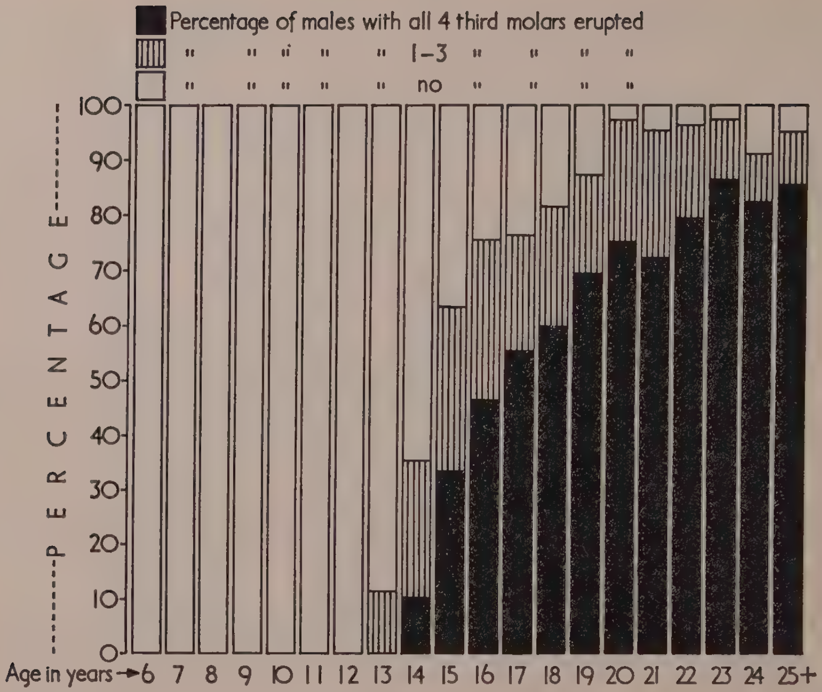


Figure 1

Frequency of absent third molars

Figure 1 shows that the percentage of males lacking some or all third molars diminishes rapidly and progressively until the 20th year and thereafter it remains fairly static. In each age group the percentage of absent third molars can be calculated from column 6 in table 1. This percentage includes that of unerupted or retained third molars and therefore it may be higher than that of congenitally absent third molars. The actual frequency of congenitally absent third molars can be determined after excluding, through radiographs of the jaws, all those cases of retained third molars.

In Negroid peoples, the percentage of congenitally absent third molars has been reported to be very low (Hellman, '28; Goldstein, '32; Thomsen, '52). Table 1 shows that, at and above the age of 25 in the African males examined, 7.7% of the third molars were absent. Examination of 188 male adult African skulls revealed only 1.9% of the third molars absent (table 2). Radiographs of the 10 jaws with absent third molars in the 188 skulls showed no unerupted third molars Since only 42 living males at and above 25 years were examined, the study of the 188 adult skulls gives a more reliable figure regarding the frequency of congenitally absent third molars in African males

This study therefore corroborates the recurrent claim made in the literature that with the exception of American Negroes (Hellman, '28), the percentage of congenitally absent third molars in Negroid peoples is very low (table 3).

Possible reasons for early eruption of thir molars in Africans

Genetic. Toverud ('56) has shown tha early loss of deciduous teeth due to an cause may lead to early eruption of th corresponding permanent teeth. Howeve even if it can be proved that African chi dren shed their deciduous teeth earlie than European or white American chi dren, this would not affect the age at eru tion of third permanent molars as thes have no temporary precursors. On th other hand, since genes act on process (Haldane, '41) it is possible that the ge complexes which control the eruption of permanent teeth begin to function earlier in Africans thus accounting for their precocity of permanent tooth eruption.

Degree of maturity at birth. Dean ('58) has shown that African children are skeletally more advanced at birth than European children. In addition the former pass the various developmental milestones much earlier than the latter. The earlier age at eruption of third molars in Africans may find partial explanation in the fact that they are born at a stage which, chronologically, is attained much later by European children.

Relation of dentition to maturity. Although there is no doubt that the age at which sexual maturity occurs is closely related to both skeletal and dental maturity (Tanner, '55), there is no evidence to show that the age at which sexual maturation occurs is lower in East Africans than in White races. Recently, Wilson and Sutherland ('53), have stated that in tropical countries, the onset of menstruation (and therefore the occurrence of sexual maturation) may be either early or late and that it may be influenced not only by food habits and nutritional status of the individual, but also by social environment, race and climate. They concluded that it is not possible, without more extensive observations, to assess the relative importance of these factors in influencing the age at which sexual maturation occurs.

Since it is possible that sexual hormones may play a part in bringing about dental maturation and eruption, a comparative study of the degree of development of the third molars in boys who attain puberty early and those who attain it late might throw some light on the role of sexual hormones in tooth development and eruption.

SUMMARY AND CONCLUSIONS

1. In East African males third permanent molars start erupting at the age of 13 and by the age of 20 the vast majority have all their third molars erupted.

2. Congenital absence of third molars has been determined in 188 adult African skulls and has been found to be 1.6% of the mandibular third molars and 1.9% of all the third molars. These findings are compared with those for other races in the literature. It is confirmed that the incidence of congenitally absent third molars in Africans is very low.

3. The forensic importance of third permanent molars is briefly discussed. It is concluded that the presence of all third molars in a male African can only mean that he is at least 14 years old.

4. Since in general third permanent molars erupt much earlier in African than in Caucasian races, some of the possible reasons are discussed. The genetic factor in early eruption of permanent teeth in Africans is stressed. It is finally suggested that a comparison of the degree of development of the third molars between boys who attain puberty early and those who attain it late might help to elucidate the role of sexual hormones in tooth development and eruption.

ACKNOWLEDGMENTS

My sincere gratitude is due to the following people for their encouragement, constructive criticisms and helpful advice during the preparation of this paper: Professor A. Galloway, Dr. D. B. Allbrook, Professor Raymond A. Dart, Dr. P. V. Tobias and Dr. R. F. A. Dean. In addition I specially thank Mr. P. G. Cull for his help in the preparation of figure 1.

LITERATURE CITED

Carothers, J. C. 1947 Age and wisdom teeth in Africans. E. Afr. Med. J., *24:* 304–306.

Clements, E. M. B., E. Davies-Thomas and K. G. Pickett 1953 Time of eruption of permanent teeth in British children in 1947–48. Brit. Med. J., *1:* 1421–1424.

Dean, R. F. A. 1958 Personal communication.

Goldstein, M. S. 1932 Congenital absence and impaction of the third molar in the Eskimo mandible. Am. J. Phys. Anthrop., *16:* 381–388.

Haldane, J. B. S. 1941 New Paths in Genetics. George Allen & Unwin, London, 206 pp.

Hellman, M. 1936 Our third molar teeth, their eruption, presence and absence. Dent. Cosm., *78:* 750–762.

Shourie, K. L. 1946 Eruption age of teeth in India. Ind. J. Med. Res., *34:* 105–118.

Steggerda, M., and T. J. Hill 1942 Eruption time of teeth among Whites, Negroes and Indians. Am. J. Orthod. Oral Surg., *28:* 361–370.

Suk, V. 1919 Eruption and decay of permanent teeth in Whites and Negroes, with comparative remarks on other races. Am. J. Phys. Anthrop., *2:* 351–388.

Tanner, J. M. 1955 Growth at Adolescence. Blackwell Scientific Publications, Oxford, 165 pp.

Thomsen, S. 11952 Missing teeth with special reference to the population of Tristan da Cunha. Am. J. Phys. Anthrop., N.S., *10:* 155–167.

Toverud, G. 1956 The influence of war and post-war conditions on the teeth of Norwegian school children. Milbank mem. Fd. Quart., 34: 354–428.

Wilson, D. C., and I. Sutherland 1953 The age of the menarche in the tropics. Brit. Med. J., *2:* 607–608.

he Cusps on the Mandibular Molars of East Africans

W. K. CHAGULA
Makerere College Medical School, Kampala, Uganda

In the dental literature of the last 60 ears, the number and pattern of cusps n the mandibular molars of Negroid eoples have been described by Topinard 1892), Schwerz ('15), Shaw ('27) and Iellman ('28) only. Their data forms the asis for comparative studies by Sullivan '20), Goldstein ('32) and Nelson ('37). Shaw ('27) however, confined himself a study of cusp numbers on the second nandibular molars of South African antu and Bushmen; he did not describe e cusp patterns on those molars. Hellnan's ('28) paper, which is frequently reerred to by many authors, was based on e study of the mandibular molars of nly 49 West African Negroes. Topinard 1892) on the other hand, omitted to nention the source of his "African Neroes," neither did he state in his paper e number of molars he had studied.

In their comparative dental studies, oldstein ('32) and Nelson ('37) did not nemselves study the cusps on the mandiular molars of any Negroid or African eoples, their data on the molars of Neroes or Africans having been derived enely from the papers of Topinard (1892) nd Hellman ('28). Sullivan ('20), whose mparative study was confined to the cond lower molar, again merely quotes hwerz ('15) regarding the cusps on the cond lower molars of Negroes. Furtherore, according to Sullivan ('20), Scherz ('15) did not state the number of cond lower molars he had examined.

It is evident therefore, that there is paucity of factual information on the numbers and patterns of cusps found on African mandibular molars, and that the little information that is available from the literature is not very reliable. The present study was undertaken mainly in order to fill this gap in anthropological data. In addition, it is aimed to supply for the first time, data on the cusps of mandibular molars of East Africans and to compare this data with that obtained from other races by other authors.

MATERIAL AND METHODS

The mandibular permanent molars of 191 East African skeletons were examined as to cusp numbers and patterns. Of these, only 23 were female, the remaining 168 being male. Although Goldstein's ('32) study of the mandibular molar cusps of the Eskimo seems to suggest that females tend to have more unstable and progressive cusp numbers, the very small number of female skeletons in the present study, probably would not significantly affect the final results.

The study was confined to those molars with clearly visible cusp and groove patterns on their occlusal surfaces, and this in part accounts for the different total numbers of first, second and third molars examined (table 1). In addition, since some molars on some of the mandibles were either absent or unsuitable for study, the number of skeletons examined were

TABLE 1

Cusp numbers on the mandibular molars of East Africans

	Number examined	Percentage of molars with indicated number of cusps			
		3	4	5	6
First molars	245		4.9	88.5	6.6
Second molars	317		81.4	18.3	0.3
Third molars	255	0.4	40.7	56.9	2.0

TABLE 2

Cusp patterns on the mandibular molars of East Africans

	Number of skeletons examined (corresponding number of molars shown in brackets)	Percentage of molars with indicated cusp pattern						
		Y5	+5	Y4	+4	Y6	+6	Y3
First molars	133 (244)	77.9	10.6	4.1	0.8	4.9	1.7	
Second molars	167 (317)	5.4	12.9	14.5	66.9	0.3	0	
Third molars	153 (255)	12.5	44.4	7.4	33.3	0	2.0	0.4

again different for each mandibular molar (table 2).

In this study, the number of cusps on each molar was first recorded. Following the practice of most previous workers in this field, the present author recorded half cusps as whole cusps. This was done in order to make the results comparable to those found in the literature.

The cusp patterns were classified according to the standard method first described by Gregory and Hellman ('26) and later modified by Hellman ('28). The principle of this method is shown in figure 1 in which it can be seen that it is base on the Dryopithecus or Y5 cusp pattern The only departure from Hellman's metho of classification in this study was the in clusion of the Y6 and +6 cusp patterns These Y6 and +6 cusp patterns have pre viously been described by only Goldstei ('48) and Schuman and Brace ('54).

RESULTS

The data obtained from this study i given in detail in tables 1 and 2. Thi data is later incorporated in tables 3 to in which results of similar studies on

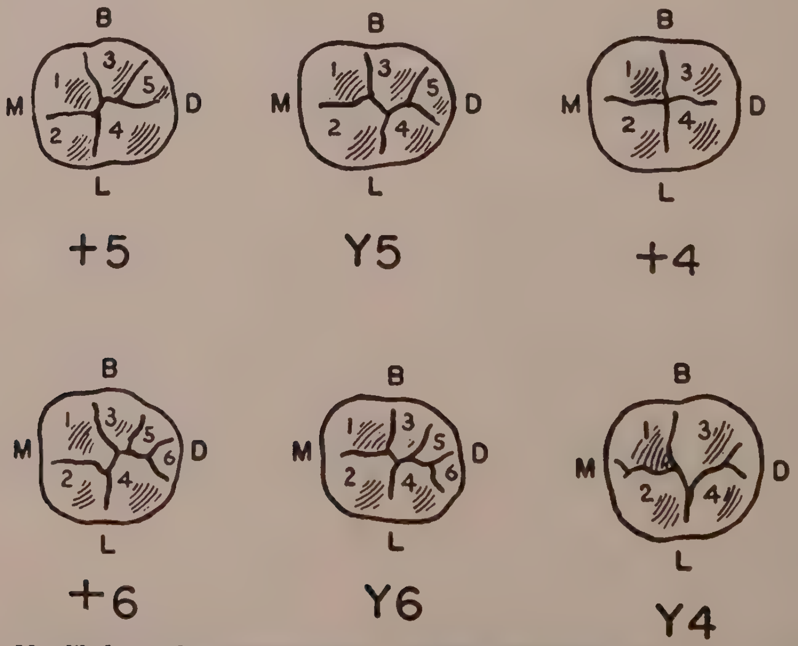


Fig. 1 Mandibular molar patterns in the Liberian chimpanzee and human dentition. M, mesial; D, distal; B, buccal; L, lingual; 1, protoconid, 2, metaconid; 3, hypoconid; 4, entoconid; 5, hypoconulid. The chief distinguishing feature between "Y" and "+" patterns is the relationship of cusps "3" and "2" to each other. In the "Y" pattern these are in contact, in the "+" pattern they are separated by cusps "1" and "4."

umber of other ethnic groups are also iven. These results can be summarized s follows:

1. In East Africans and all the other thnic groups shown in the tables, the ast majority of first permanent mandiblar molars have 5 cusps (tables 1 and). In addition, in East Africans, as in ll the other racial groups shown in able 6, the first permanent mandibular olar is the most primitive or conservave in that it shows the Dryopithecus or 5 cusp pattern most frequently.

2. In East Africans and all other ethnic groups except the Eskimos studied by Goldstein ('32) and the South African Bantu (Shaw, '27), the majority of second permanent mandibular molars have 4 cusps—while the percentage of second molars with 5 cusps is very low (table 4). The majority of second mandibular molars in East Africans possess the +4 cusp pattern (table 2).

3. East Africans show a swing back to 5 cusps on the occlusal surfaces of the majority of their third molars (table 1).

TABLE 3

Cusp numbers on first mandibular molars

Racial group and author	Number of molars	Percentages of molars with indicated cusps					
		5	4	4½	5½	4	6
Europeans							
Rose 1892	466	92.3	7.7				
Bolk 1914	304	72.4	27.6				
Eskimo							
Goldstein 1932	137	59.8	5.1	18.2	1.5	15.3	
Malay							
Topinard 1892	?	83.3	7.4	3.7			5.5
Australian aboriginals							
Campbell 1925	88	94.0	3.7	2.5			
African Negroes							
Topinard 1892	?	88.1	8.5		3.4		
East Africans							
Chagula	244	88.5	4.9				6.6

TABLE 4

Cusp numbers on second mandibular molars

Racial group and author	Number of molars	Percentages of molars with indicated cusps						
		5	4	4½	5½	6	3	$4\frac{2}{2}$
Europeans								
Rose 1892	435	15.9	83.0				1.1	
Bolk 1914	438	2.0	98.0					
Eskimo								
Goldstein 1932	188	28.2	21.8	22.3	2.1	0.5		22.9
Australian aboriginals								
Campbell 1925	125	32.0	63.4	4.8				
Negroes								
Terra 1905	28	28.5	71.5					
Schwerz (Sullivan 1920)	?	34.0	66.0					
South African Bantu								
Shaw 1927	196	55.1	44.9					
East Africans								
Chagula	317	18.3	81.4			0.3		

TABLE 5

Cusp numbers on third mandibular molars

Racial group and author	Number of molars	Percentages of molars with indicated cusps						
		5	4	4½	5½	6	3	4$\frac{2}{2}$
Europeans								
Rose 1892	356	42.1	51.4			1.7	4.8	
Bolk 1914	304	45.7	54.3					
Eskimo								
Goldstein 1932	153	49.7	5.2	15.0	3.3	0.6		20.9
Australian								
Campbell 1925	110	72.7	27.3					
Negroes (African)								
Terra 1905	24	58.3	41.5					
East Africans								
Chagula	255	56.9	40.7			2.0	0.4	

This is in line with the findings in other ethnic groups except Europeans (table 5). The majority of third mandibular molars in East Africans and other ethnic groups, with the exception of Europeans and Chinese, possess the +5 cusp pattern (table 8).

Comparison of results with those for other races

Cusp numbers

First mandibular molars. In the majority of the racial groups shown in table 3, the percentage of first molars with 5 cusps is well over 70%. An apparent exception are the Eskimos in whom Goldstein ('32) found that well below 70% of the first molars had 5 cusps. This exception, however, disappears when it is remembered that Goldstein recorded half cusps as such. Thus, to most authors, 4½ cusps would most probably count as 5 cusps. If we therefore add Goldstein's percentage of first molars having 4½ cusps to that of first molars with 5 cusps, a figure of 78% is obtained. This is the percentage of first molars with 5 cusps that Goldstein would have obtained if he had regarded half cusps as whole cusps. In all racial groups shown in table 3, the percentage of 4-cusped first molars is generally speaking very low.

Second mandibular molars. In most racial groups including East Africans, well over 50% of second molars possess 4 cusps (table 4). The Eskimos studied by Goldstein ('32) appear again to b one exception to this generalization. Thi exception may have resulted from the extremely complicated method of recordin cusps that Goldstein adopted. Thus according to most authors, Goldstein's percentages of second molars with 4½ an 4⅔ may well have been included in tha of second molars with 4 cusps. Thi would have raised his figure to well ove 60%. The other exception is the Sout African Bantu examined by Shaw ('27 This author found only 44.9% of secon molars with 4 cusps, while the remainin 55.1% had 5 cusps. The present autho however, found that 81.4% of second molars in his East African material had cusps and only 18.3% had 5 cusps (tabl 4). Since most of the second molars i the present study belonged to Bant tribes, the marked difference in cusp numbers between the results obtained fron South African Bantu and those from Eas African Bantu is interesting. A furthe more extensive study of the dentitions o both Bantu groups is urgently needed— especially as the criteria used for distin guishing the Bantu are linguistic and no physical. A difference may well exist be tween the South African and East Africa Bantu in respect to their dentitions.

Third mandibular molars. Table shows that in all racial groups excep Europeans, the majority of third mola possess 5 cusps. In general, in all race including Europeans third molars posses

cusps much more frequently than sec-
nd molars. The Australian Aboriginals
eem, however, to have a much higher
ercentage of 5 cusped third molars than
ll the other races and they would there-
ore appear to be in a different class
together.

It should be mentioned that in the East
frican material, the author found a
mall percentage of both 6-cusped and
aree-cusped third molars. This is not a
nding peculiar to East Africans, for both
ose (1892) and Goldstein ('32) have
ecorded such third molars among Euro-
eans and Eskimos respectively.

usp patterns

First mandibular molars. In all the
ices shown in table 6, the first molar is
ne most conservative since it still retains
ne Y5 or Dryopithecus cusp pattern to
ne highest degree (tables 6 to 8). It is
 interest to note that this general state-
ent applies also to the Liberian Chim-
anzee whose mandibular molar percent-
ge cusp patterns, as described by Schu-
an and Brace ('54), are included in
bles 6 to 8.

From a comparative standpoint, how-
ver, many of the figures given in table 6
e of very little value. Thus from table 6
one, one cannot categorically conclude
at the first mandibular molars of Chi-
ese and Australians are more primitive
an those of Eskimos, Europeans and
frican Negroes. This is because in most
ses, especially in respect to Chinese and
ustralians, Hellman ('28) studied very
w individuals as compared to Pedersen
49). From table 6 it is obvious that
ellman's and Pedersen's figures are not
 all comparable and that no conclusions
ould be drawn from them. Again, it is
sy to conclude from table 6 that the
st molars of East Africans are more
lvanced as to cusp pattern than those
 Europeans studied by Hellman. This
nclusion would not be acceptable either
 view of the fact that the relative num-
rs of first molars examined by Hellman
d the present author are not compar-
le.

Second mandibular molars. In table 7
 can be seen that in all racial groups,
ost second molars possess the +4 cusp

TABLE 6

Percentage distribution of cusp patterns on mandibular first molars
The number of individuals examined is shown in parentheses

Racial group	Author	Number of molars	Percentage incidence of indicated cusp pattern						
			Y5	+5	Y4	+4	Y6	+6	Unclassed
Chinese	Hellman 1928	26 (19)	100						
Eskimos	Pedersen 1949	143 (?)	94.4	2.8	0	1.4			
Pecos Indians	Nelson 1937	332 (164)	88.6	10.8	0	0.6			1.4
European Whites (male)	Hellman 1928	98 (61)	87.0	2.0	7.0	4.0			
Chicago Whites	Dahlberg 1949	? (75)	84.0	2.0	8.0	2.0			
Australians	Hellman 1928	18 (20)	100.0						
African Negroes	Hellman 1928	97 (49)	99.0		1.0				
East Africans	Chagula	244 (133)	77.9	10.6	4.1	0.8	4.9	1.7	
Liberian Chimpanzee	Schuman and Brace 1954	96 (48)	54.0	16.0	0	2.0	25	4	

TABLE 7

Percentage distribution of cusp patterns on mandibular second molars
The number of individuals examined is shown in parentheses

Racial group	Author	Number of molars	Percentage incidence of indicated cusp patterns						
			Y5	+5	Y4	+4	Y6	+6	Unclassed
Chinese	Hellman 1928	21 (19)		19.0		81.0			
Eskimo	Pedersen 1949	115 (?)	19.0	42.0	4.0	35.0			15.0
Pecos Indians	Nelson 1937	313 (164)	8.3	24.3	1.3	66.1			
European Whites	Hellman 1928	110 (61)		1.0	5.0	94.0			
Australians	Hellman 1928	21 (20)	5.0	43.0		52.0			
African Negroes	Hellman 1928	96 (49)	17.0	8.0	12.0	63.0			
East Africans	Chagula	317 (167)	5.4	12.9	14.5	66.9	0.3		
Liberian chimpanzee	Schuman and Brace 1954	99 (50)	16.0	59.0	0	1.0	9.0	16.0	

pattern. The Liberian chimpanzee, on th other hand, shows a predominance of th +5 cusp pattern on its second molars.

The same difficulties as were discusse regarding the first mandibular mola arise in connection with second molar Thus the findings in the Chinese an Australians as shown in table 7 shou not be regarded as conclusive, due to th extremely small number of molars stu ied. Also, it is difficult to say by lookin at table 7, whether the second molars European Whites are more advanced, r garding their cusp patterns, than tho of either Pecos Indians or East Africans- due again to the marked differences the relative numbers of molars examin in the respective racial groups.

Third mandibular molars. In gener in all the racial groups shown in tab 8—with the sole exception of Europe Whites—the third molars show the + cusp pattern more frequently than th +4 cusp pattern. This also applies the Liberian chimpanzee.

In this study, many third molars di not show any definite cusp pattern an these were excluded from the study. respect to cusp patterns on the third m lars of East Africans, the present auth confirms Dahlberg's ('49) statement th ". . . the third molar is an extreme variable tooth and cannot be trusted t much as to pattern."

For comparative purposes, the same o jections as were stated while discussi the cusp patterns of first and second low molars in various races, can also be rais here against the usefulness of some data in table 8. For instance, it would misleading to draw any conclusion fro the percentage incidence of the vario cusp patterns on the mandibular thi molars of Australians if this figure w arrived at after examining only 23 mola Equally, as table 8 shows, it would not permissible to conclude that the thi molars of East Africans are more cons vative or primitive as to cusp pattern th those of European Whites in view of t fact the present author studied over thr times as many molars as Hellman ('2 did.

TABLE

Percentage distribution of cusp patterns on mandibular third molars
The number of individuals examined is shown in parentheses

Racial group	Author	Number of molars	Percentage incidence of indicated cusp patterns						
			Y5	+5	Y4	+4	+6	Y3	Unclassed
Chinese	Hellman 1928	16 (19)		50.0		50.0			
Eskimo	Pedersen 1949	55 (?)	12.7	61.5	9.1				16.4
Pecos Indians	Nelson 1937	249 (164)	8.4	51.0	4.8	35.8			
European Whites	Hellman 1928	74 (42)	4.0	34.0		62.0			
Australians	Hellman 1928	23 (20)	14.0	72.0		14.0			
African Negroes	Hellman 1928	88 (49)	20.0	59.0	3.0	17.0			
East Africans	Chagula	255 (153)	12.5	44.4	7.4	33.3	2.0	0.4	
Liberian chimpanzee	Schuman and Brace 1954	114 (57)	1.0	71.0	0	24.0	5.0		

CONCLUSIONS

It is clear therefore that, except in a few instances, we are not at present in a position to say to what extent the mandibular molars of the various racial groups have evolved from what they were in Dryopithecus—regarding their cusp patterns. What is urgently needed is a repetition of the work of such earlier workers as Topinard (1892), Rose (1892) and Hellman ('28)—using an adequate number of molars and a uniform method of recording the molar cusp numbers and patterns. The present author is thus in full agreement with Goldstein ('32) when he said, "Topinard long ago noted that statistics on the cusps of the lower molars varied with each observer. Whether the discrepancies may be due to differences in number of specimens examined, or the method, detailed care, is oft-times impossible to ascertain, because the number of specimens and other data are not given." Goldstein ('32) further states that ". . . the above-mentioned discrepancies introduce a disturbing element of uncertainty as to the validity of the recorded racial differences in the molar cusp numbers. A real need exists for definite criteria and rules to guide observers of cusp numbers (and patterns) in the molar teeth. . . ."

The fact that Goldstein's remarks are still as true today as when they were first made 26 years ago reflects the unsatisfactory state of our knowledge regarding differences in the cusps of the mandibular molars of various races. The world is therefore still badly in need of dental data, obtained by standardized methods of observation and recording, which will form a reliable basis for human comparative dental studies.

SUMMARY AND CONCLUSIONS

1. The author has described for the first time the cusp numbers and patterns on the mandibular molars of 191 East African skeletons.

2. It has been found that the most frequent cusp number in East African mandibular molars is 5 in the first molars, 4 in the second molars and 5 in the third molars. The most frequent cusp pattern in the first mandibular molars in East Africans is Y5; in the second molars it is

+4; while in the third molars it is +5. These East African results broadly agree with those for other races in the literature.

3. The East African findings are later critically compared with those for other races by other authors. In connection with mandibular molar cusp numbers and patterns, it is concluded that most of the data in the world dental literature is of very little value for compartive purposes and therefore it should not be employed in making statements about racial differences.

4. It is strongly suggested that a repetition of most of the studies of the older dental students—using an adequate number of observations and a uniform method of recording those observations—is what is urgently needed now.

ACKNOWLEDGMENTS

The author would like to thank Professor A. Galloway for his encouragement and Dr. D. B. Allbrook for his invaluable criticism and suggestions during the preparation of this paper. He would also like to extend his sincere gratitude to Wayne State University Press, the Publishers of Human Biology for allowing him to reproduce figure 8 from the paper on the Dentition of the Liberian Chimpanzee by Schuman and Brace, which appeared in Human Biology, volume 26, number 3.

LITERATURE CITED

Bolk, L. 1914 Die Morphogenic der Primatenzahne: Odontologische Studien II. Jena. Cited by Goldstein, M. S. (1932).

Campbell, T. D. 1925 Dentition and palate of the Australian Aboriginal. Keith Sheridan Foundation Publications, University of Adelaide.

Dahlberg, A. A. 1949 The dentition of th American Indian in The Physical Anthropolog of the American Indian. The Viking Fund, Inc New York, pp. 138–176.

Goldstein, M. S. 1932 The cusps in the mand bular molar teeth of the Eskimo. Am. J. Phy Anthrop., *16:* 215–235.

——— 1948 Dentition of Indian crania fro Texas. Am. J. Phys. Anthrop., n.s., *6:* 63–83.

Gregory, W. K., and M. Hellman 1926 Th dentition of Dryopithecus and the origin man. Anthropological Papers Am. Mus. Na Hist., *28:* 1–123.

Hellman, M. 1928 A racial distribution of th Dryopithecus pattern and its modifications i the lower molar teeth of man. Proc. Am Philos. Soc., *47:* 157–174.

Nelson, C. T. 1937 The teeth of the Indians Pecos Pueblo. Am. J. Phys. Anthrop., *23:* 261 293.

Pedersen, P. O. 1949 The East Greenlan Eskimo dentition. Medelelser om Gronlan vol. 142. Bianco Lunos Bogtrykkeri, Cope hagen.

Rose, C. 1892 Ueber die Entstehung und Form banderungen menschlichen Molaren. Ana Anz., *7:* 2421. Cited by Goldstein (1932).

Schuman, E. L., and C. L. Brace 1954 Metr and morphologic variations in the dentition the Liberian chimpanzee; comparisons wit anthropoid and human dentitions. Hum. Biol *26:* 239–268.

Schwerz, F. 1915 Die Volgerschaften der Sch weiz von der Urzeit bis zu Gegenwart, Buscha Studien und Forschungen zur Menschen- un Volkerkunde, Vol. XIII, Stuttgart. Cited b Sullivan (1920).

Shaw, J. C. M. 1927 Cusp development on th second lower molars in the Bantu and Bush men. Am. J. Phys. Anthrop., *6:* 1.

Sullivan, L. 1920 Differences in the patter of the second molar tooth. Am. J. Phys. An throp., *3:* 255–257.

Terra, Max de. 1905 Odontographie der Men schen-Rassen. Zurich. Cited by Goldstei (1932).

Topinard, P. 1892 De l'evolution des molaire et premolaires chez les Primates. L'Anthro pologie, 641–710.

Study of the Bilaterality of Human Hair

R. I. SPEARMAN AND N. A. BARNICOT

Dermatology Department, University College Hospital Medical School, W.C.1., and the Anthropology Department, University College London, W.C.1

Wool fibers from various breeds of eep have different keratin properties on e convex and concave sides of the crimp. e convex side (the "orthocortex" of ercer, '53) stains strongly with hot basic es (Horio and Kondo, '53) and is fairly sily attacked by keratolytic agents (Dus- bury and Menkart, '55). On the concave e the "paracortex" (Mercer, '53) does t stain with hot basic dyes and is more sistant than the convex side to chemical d enzymatic decomposition. In trans- rse sections of stained fibers the "or- o" and "para" segments are most sharply fined in wool of small diameter (Fraser d Rogers, '55) and it is the fine wool ers which have the greatest crimp curva- e. In coarser crimped wools a bilateral angement of "ortho" and "para" kera- s is not always seen. In wool from pig- nted breeds (Laxer, Whewell and ods, '54) there is an asymmetric dis- bution of melanin which is associated h the crimp; melanin granules are re concentrated on the concave side of fiber.

Because of the close association between crimp of wool and bilaterality of the atin, Fraser and Rogers ('55) have ggested that this phenomenon may oc- in all sufficiently curly mammalian rs. Mention of human hair in connec- n with wool bilaterality was made by senbury and Menkart ('55) and Men- t and Coe ('58) but it was not made ar whether the hair examined was in t of a highly curly type. In one case hair was stated to be that of a blonde ropean, which one would not expect to extremely curly. No detailed study of more spiralized Bushman, Hottentot l Negro hair has been made from this nt of view.

PRESENT INVESTIGATION

In the present investigation human scalp hairs from various races have been closely compared with merino wool, to determine whether any keratin bilaterality or asymmetry of pigment is present, and to see if any variation exists between the different forms of hair.

MATERIAL

For the keratin examination, 6 specimens of albino Negro hair from Southern Nigeria, in which pigment is very much reduced, were used because heavy pigmentation obscures staining and the appearance of birefringence under polarized light. Small diameter merino wool which shows good keratin bilaterality was used for comparison. In addition 6 samples of pigmented Nigerian hair, one of Bantu from S. Africa, 6 of Bushman, one of Hottentot, one of blond naturally wavy European hair, and a mixed sample of straight Chinese hair were examined in less detail. All pigmented hairs were examined for asymmetric melanin distribution.

Staining reactions

Samples of wool and negro hair were embedded in the same paraffin wax block and cut at 6 μ transversely to the long axis of the fibers; direct comparison of sections of hair and wool mounted on the same slide was thus achieved.

The sections were immersed in 0.1% solution of several different stains for two hours at 60°C and then decolored in dilute hydrochloric acid according to the technique of Horio and Kondo ('53). Methyl violet, basic fuchsin and safranin, which are basic dyes, and Ponceau S an acid dye were used.

The bilateral staining of the wool was clearly seen; only the "orthocortex" was markedly basophilic (fig. 5) and as found by Horio and Kondo ('53) only the "paracortex" was stained with the acid dye (fig. 3). The Negro hair showed strong overall staining with basic dyes (fig. 6) but practically no staining with the acid dye, Ponceau S at pH 7 (fig. 4). This suggested a similarity of the whole human hair cortex to wool "orthocortex." Staining with methyl violet was somewhat patchy but it was thought that this was due to an uneven staining of individual cortical cells rather than to variations in staining between the different cortical cells. In fragments of hair cut longitudinally along the fiber and stained with methyl violet, and also in individual cortical cells separated by the papain, urea, bisulphite technique of Lennox ('52), the middle part of the cortical cell tended to be more basophilic than the tapering ends. This might account for any uneven staining seen in transverse sections.

With Ponceau S staining it was clearly the smaller "para" segment of the wool that was stained. This confirmed the original findings of Horio and Kondo, but orthocortical staining with acid dyes reported by Dusenbury and Coe ('55) was not encountered.

Supercontraction and trypsin digestion

Keratin is normally resistant to trypsin digestion but Mercer ('53) has shown that the orthocortex unlike the paracortex of wool can be supercontracted in superheated steam. After this treatment the orthocortex can be digested by trypsin but the paracortex remains resistant.

Samples of Nigerian hair and wool were autoclaved at 120°C for 90 minutes to supercontract the wool orthocortex. They were then digested in 2% trypsin solution adjusted to pH 8.6. The partially digested hair and wool fibers were taken through alcohols, mounted in ortho-dichlorbenzene, which has roughly the same refractive index as keratin, and examined under polarized light. By mounting the hairs in this way, reflections from the fiber surface were avoided and the observed birefringence was due largely to the crystalline nature of the keratin. Wool orthocortex completely lost its birefringence after trypsin d
gestion but there was no comparable lo
in human hair.

Transverse sections of trypsin-digeste
hair and wool were mounted on the sam
slide and stained in 0.1% aqueous ac
dine orange for fluorescence microscop
(Jarrett, Bligh and Hardy, '56). Aft
supercontraction the orthocortex of th
wool fluoresced orange indicating that th
keratin in this region had been altere
The fluorescence of the orthocortex w
greatly enhanced after further trypsin d
gestion and only at this stage was bir
fringence lost; this was in marked co
trast to the paracortex which was una
fected by these procedures and retain
the same blue-green fluorescence with ac
dine orange as untreated wool and ha

After supercontraction Nigerian hai
fluoresced blue-green with acridine oran
but after additional trypsin digestion th
whole cortex fluoresced orange with th
fluorochrome and was similar to the orth
cortex of wool. However, human hair, u
like wool orthocortex, did not complete
loose its birefringence after the same d
gree of trypsin treatment. In its resistan
to trypsin digestion after autoclaving, N
gerian hair appears, therefore, to be i
termediate between wool ortho- and par
cortex and no bilateral difference in ker
tin properties was detected.

Effects of acid and alkali

The solubilities in alkali, of one samp
of Bantu hair, and one of merino wo
keratin after hydrolysis for various tim
in boiling dilute sulphuric acid was e
amined; the insoluble residue was mea
ured gravimetrically. The technique us
has been described by Dusenbury, Merc
and Wakelin ('54). The results obtain
confirmed their findings that human ha
was more resistant than wool to prolong
acid hydrolysis followed by alkali tre
ment.

Sections and whole hairs were examin
microscopically in various concentratio
of sodium hydroxide. Sections of ha
showed uniform swelling in all concent
tions. While whole curly hairs straigh
ened out in the alkali, loss of birefringen
over the fiber was uniform suggesting th
no keratin bilaterality in fact existed.

Peracetic acid oxidation

Hairs and wool were cut into short lengths and immersed in 3% peracetic acid for 24 hours. This treatment specifically oxidizes the disulphide linkages of the keratin (Alexander and Hudson, '54). After washing in water the hairs were stained in 0.1% methylene blue (Fraser and Rogers, '55). The wool "paracortex" was more deeply stained than the "orthocortex" but Negro hair showed uniform heavy staining, suggesting an even cystine disulphide distribution.

Histology

One specimen of Negro scalp sectioned and stained in hematoxylin and eosin was examined microscopically. The hair follicles showed the same curved form with a retroverted bulb region as Auber ('52) described in the follicles of crimped wool. Differences in the thickness of the outer root sheath on the concave and convex sides of the developing hair, as shown to occur in the sheep, were not detected in the few human hair follicles examined.

Pigmentation

When normally pigmented Negro hairs were examined under the microscope the abundant pigment seemed to be uniformly distributed in the fiber. However, when hairs were treated with N/10 sodium hydroxide the keratin swelled and melanin granules became separated. A greater density was then seen on the concave side of the curl. A similar asymmetric distribution was noticeable in transverse sections of some Negro albino specimens which were slightly pigmented. The uneven distribution of melanin in heavily pigmented Negro hair was revealed by partial bleaching in hydrogen peroxide (10 vols. buffered to pH 6.0), overnight at room temperature (fig. 1). Samples of Bushman and Hottentot hair were not so heavily pigmented as the Bantu and W. African hair and asymmetric melanin density was easily seen in whole mounts or in transverse sections (fig. 2) without further treatment. There was some indication of pigment asymmetry in the wavy European hair examined, but this was not nearly so pronounced as in the more spiralized hairs. No asymmetric melanin distribution was seen in the straight Chinese hair. These findings indicate that, as was found in sheep and vicuna (Laxer, Whewell and Woods, '54), bilateral differences in pigmentation are most readily observable in more curled hairs.

DISCUSSION

It appears from the present work in which a variety of techniques have been used that there is no appreciable differentiation of the keratin of human hair cortex into ortho and para types. The keratin of Negro hair behaves similarly to wool orthocortex in its reactions to stains but is intermediate between wool ortho and paracortex in resistance to supercontraction and trypsin digestion. Dusenbury and Menkart ('55) regarded human hair cortex as a pure para type of keratin on the basis of peracetic acid oxidation and alkali solubility studies. According to Mercer, Golden and Jeffries ('54) paracortex is characterized by a high content of disulphide bonds which determine its relative stability. Fraser and Macrae ('56) have shown some para type staining in mohair which is regarded as pure orthocortex on the basis of other techniques. It would apear that comparisons of different keratins do not necessarily give the same results when different methods of investigation are used, presumably because the reactions to the various procedures depend on different chemical properties of the keratin.

Although in wool a high degree of crimp is associated with both pigment and keratin bilaterality, in human spiralized hair the former occurs without the latter. The reason for the pigment asymmetry in terms of the underlying activity or distribution of melanocytes in the hair bulb is not at present clear.

SUMMARY

1. Spiralized Negro and Bushman hair has been compared with crimped merino wool to see whether bilateral differences in the cortex associated with hair curl could be detected.

2. No bilateral difference in human keratin was demonstrated even in very curly hairs. The keratin was intermediate be-

tween ortho and paracortex by some of the techniques used.

3. A marked asymmetry of pigmentation was found in Negro and Bushman hair with the greater concentration of melanin on the concave side of the curl. No asymmetry was found in straight Chinese hair.

ACKNOWLEDGMENTS

We are grateful to Dr. W. N. Goldsmith for the interest he has shown in this work, and we wish to thank Dr. A. Jarrett and Dr. E. H. Mercer for their advice and criticism.

We are indebted to the following for samples of hair: Dr. H. Eriksen and Dr. P. V. Tobias of Witwatersrand University, and Dr. M. J. Toerien of Stellenbosch University, South Africa; Mr. Huan Hsiang, Chargé d'Affaires of the People's Republic of China, and Mr. K. P. Oakley of the British Museum (Natural History). We wish to thank Mr. A. Bligh for advice on photography.

One of the authors, Mr. R. I. Spearman, holds a personal Grant from the Medical Research Council.

LITERATURE CITED

Alexander, P., and R. F. Hudson 1954 Wool—its Chemistry and Physics. Chapman & Hall, London, p. 265.

Auber, L. 1952 The anatomy of follicles producing wool fibres with special reference to keratinisation. Trans. Roy. Soc. Edinb., *62:* 191–254.

Dusenbury, J. H., and A. B. Coe 1955 Differential dyeing as an indicator of bilateral structure in wool: New finding. Text. Res. J., 25 354–358.

Dusenbury, J. H., and J. Menkart 1955 Th present state of the ortho and paraconcept Proc. Int. Wool Text. Res. Conf. Austr., F, 142–150.

Dusenbury, J. H., E. H. Mercer and J. H. Wakeli 1954 The influence of chemical treatment o the properties of wool. I. Alkali solubility as measure of sulphuric acid degradation. Tex Res. J., *24:* 890–899.

Fraser, R. D. B., and T. P. Macrae 1956 Th distribution of ortho and para-cortical cells i wool and mohair. Ibid. *26:* 618–619.

Fraser, R. D. B., and G. E. Rogers 1955 Th bilateral structure of wool cortex. Proc. In Wool Text. Res. Conf. Austr., F, 151–155.

Horio, M., and T. Kondo 1953 Crimping wool fibres. Text. Res. J., *23:* 373–386.

Jarrett, A. 1958 Chemistry of the inner ro sheath and hair keratins. Brit. J. Derm., 7 271–283.

Jarrett, A., A. Bligh and J. A. Hardy 195 Fluorescent microscopy of the human ski Ibid., *68:* 111–119.

Laxer, G., C. S. Whewell and H. J. Woods 19 Asymmetry of distribution of melanin in pi mented wools and its correlation with fib crimp. J. Text. Inst., *45:* T, 482–486.

Lennox, F. G. 1952 Digestion of wool kerat by papain-bisulphite-urea and related system Aus. J. Sci. Res., *B5:* 189–209.

Menkart, J., and A. R. Coe 1958 Microscop studies on the structure and composition keratin fibres. Text. Res. J., *28:* 218–226.

Mercer, E. H. 1953 The heterogeneity of t keratin fibres. Ibid., *23:* 388–397.

Mercer, E. H., R. L. Golden and E. B. Jeffri 1954 Distribution of cystine in the cortex wool. Ibid., *24:* 615–618.

PLATE 1

EXPLANATION OF FIGURES

1 Two Nigerian hairs (1a and 1b) after bleaching in hydrogen peroxide. Pigmentation is seen to be denser on the concave aspect. Whole mounts unstained in Canada balsam. × 200.

2 Transverse sections of two Hottentot hairs (2a and 2b) unstained; to show bilateral difference in distribution of melanin granules. × 700.

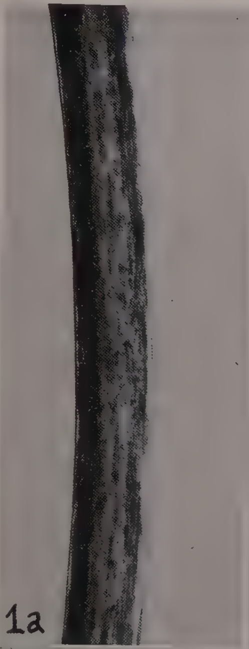
3 Transverse sections of merino wool fibers. Stained in Ponceau S. adjusted to pH 7 Horio and Kondo's method. The "paracortex," which comprises the smaller segment, is stained. × 700.

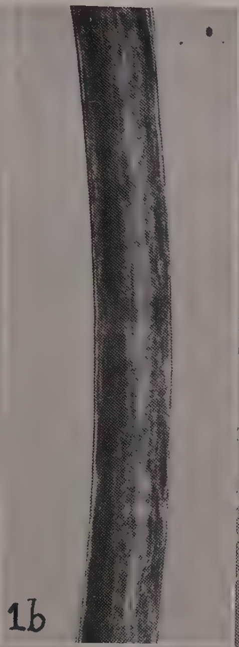
4 Transverse section of human hair (Nigerian albino) stained on the same slide as the wool in figure 3. The fiber has not taken up the stain and is comparable to the "orthocortex" of the wool. × 700.

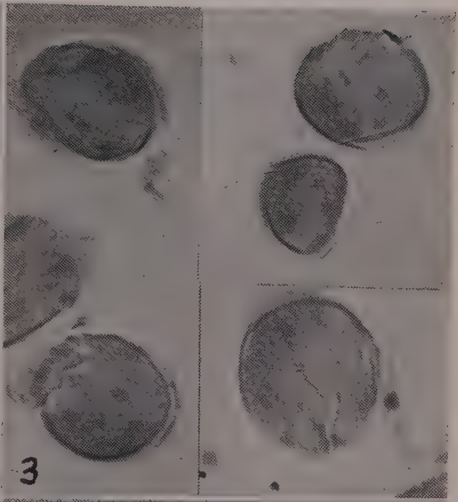
5 Transverse sections of merino wool fibers stained in methyl violet; Horio and Kondo's method. The "orthocortex" has taken up the stain. × 700.

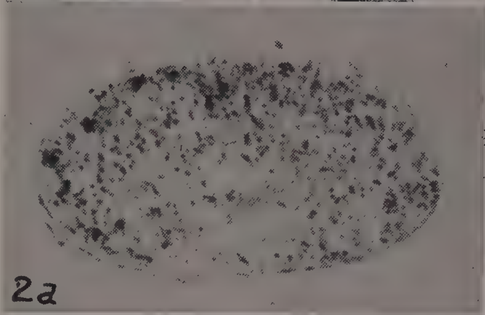
6 Transverse section of human hair (Nigerian albino) stained on the same slide as the wool in figure 5. The whole fiber has taken up the stain and is comparable to the "orthocortex" of wool. × 300.

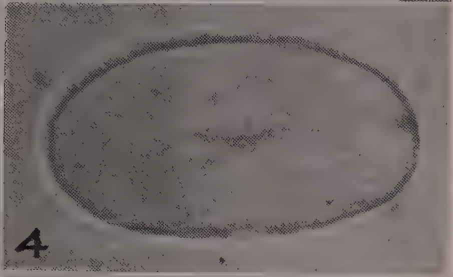
PLATE 1


1a

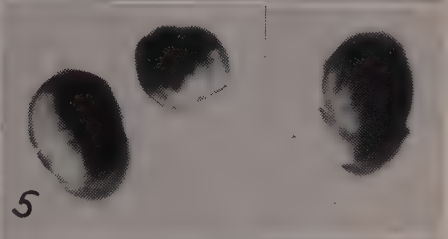

1b

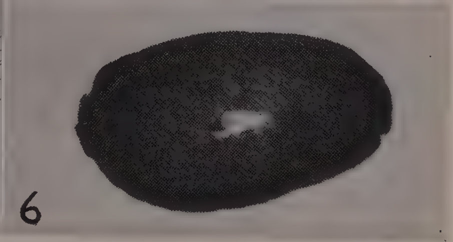

3


2a


4

2b


5


6

Measurement and Surface Features of the Cranial Fossae in Closed Skulls

C. A. ERSKINE AND C. C. C. O'MORCHOE
School of Anatomy, Trinity College, University of Dublin

In an investigation into the characteristics of the trigeminal impression and the possible relation of these characteristics to other features and diameters of the middle fossa in the human skull, a problem was presented by the relative inaccessibility of the various parts without removal of the calvarium.

This short paper describes a relatively simple technique whereby surface features of the interior of the skull may be displayed; if required, exact measurements of any particular feature may be made and related to the measurements of the interior of the base as a whole. This technique would be of value in the survey and examination of specimens from institutional collections where removal of the calvarium might be undesirable. Radiology already provides a means for accurate measurement of internal diameters, but it is less useful in revealing surface details, e.g., canalization of blood vessel grooves, diameters of grooves or crests in complex angles of bones, relative smoothness of surfaces, volumetric estimations or measurement of shallow depressions.

METHOD

Essentially the method depended on the simple process of taking impressions of the base by means of dental wax mounted on a carrier plate and passed through the foramen magnum; plaster casts were made from the wax impressions and aligned by means of a key strip.

The carrier plates for the wax consisted of rectangular pieces of malleable copper plate approximately 5 cm × 2.5 cm attached to a wire handle (fig. 3) on which the softened wax (approximately 1 cm thick) was molded. The correct plasticity of the wax (Stents Composition)[1] was obtained by immersion in water at 60°C. Before taking an impression the surface of the composition was flamed with a bunsen and immersed quickly in hot water. Distortion on removal of the wax from the skull and subsequent handling was effectively prevented by the backing support given by the carrier plate. The handles could be bent easily and the plates pressed on the required areas in succession. Each cranial fossa required about three overlapping wax impressions. These were pared with a scalpel to fit the corresponding impression on either side and the whole mounted on plasticine. From this a plaster cast was taken and thus the cranial fossa was reconstructed (fig. 1); no difficulty was experienced in the reconstruction of the less accessible anterior fossa by this method (fig. 2).

The most suitable length for the wire handles depended on the area from which the impression was required. Likewise, the plate may be curved to suit the various concavities encountered. Thus a selection of instruments of different shapes and sizes simplified the procedure.

In order to allow accurate measurement in any diameter of the base a proper alignment of the piece-casts derived from the wax impression was made by taking an impression on each side of three key points on one strip; the edge of the foramen magnum on one side was aligned with the opposite groove for the superior petrosal sinus and lesser wing of the sphenoid bone. The two strips used for this procedure for each side of the base provided a template for reconstruction of the base from the separate casts of the cranial fossae. The cut casts were mounted on a layer of plasticine while adjustment was made to the key strips (fig. 4).

---

[1] Amalgamated Dental Trade Distributors Ltd., London; a similar product is Kerr's Impression Compound, Kerr Manufacturing Co., U.S.A.

Thus an accurate and permanent model which revealed fine detail of the whole base was obtained from the interior of the intact skull.

SUMMARY

Impressions of the base of the skull wer taken by means of dental wax mounted o adjustable carrier plates which were passe through the foramen magnum; plaste casts were made from the wax impression and aligned by means of a key strip; align ment allowed accurate measurement (c provided the basis for volumetric estima tions) of various internal areas of th base.

PLATE 1

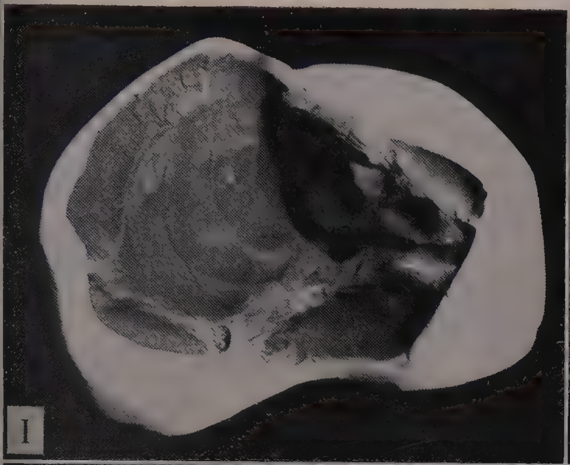
EXPLANATION OF FIGURES

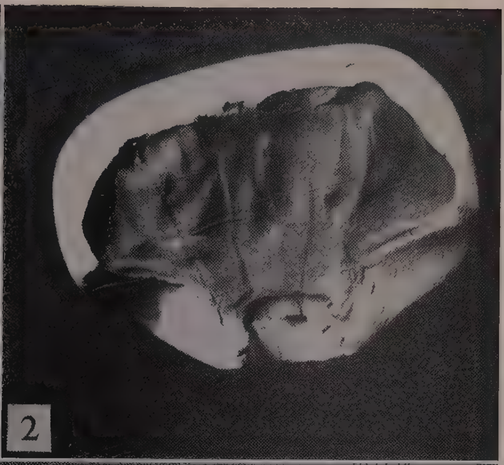
1 Internal surface of the left half of the posterior cranial fossa (which has been lightly rubbed with brown chalk); fine detail of surface features can be seen.

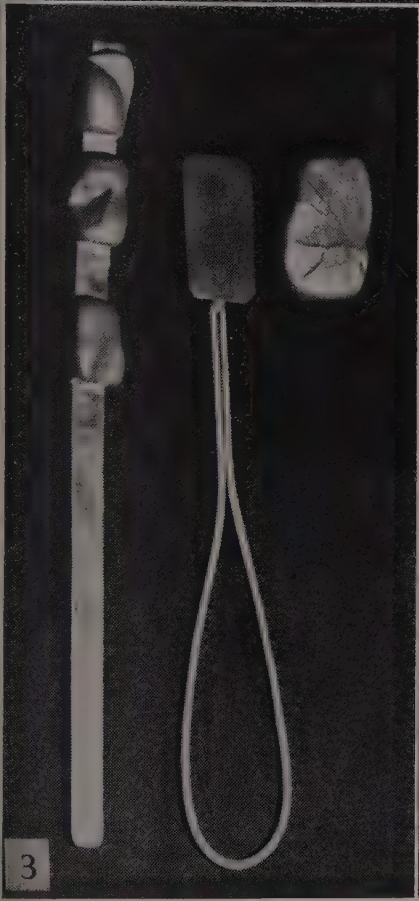
2 Plaster cast of the reconstructed anterior fossa.

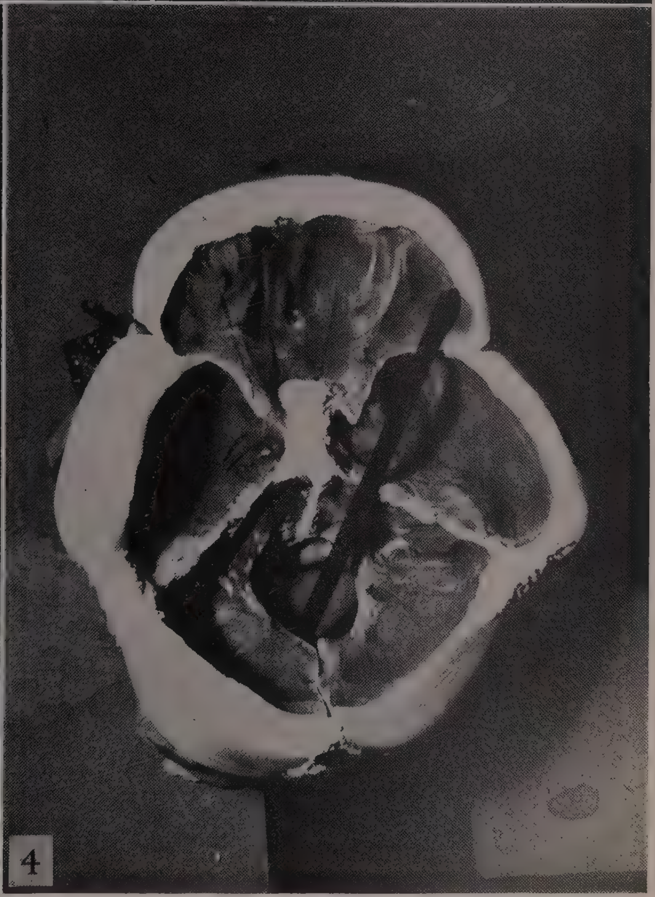
3 Brass strip and copper plates with wire handles and pieces of wax used for the reconstruction.

4 Whole base of skull aligned for measurements; brass strip shown in contact with left side of foramen magnum and opposite petrous temporal bone and lesser wing of sphenoid.


1


2


3


4

A Blood Group Genetical Survey in New Britain[1]

R. T. SIMMONS,[2] D. C. GAJDUSEK[3] AND LOIS C. LARKIN
Commonwealth Serum Laboratories and Walter and Eliza Hall Institute of Medical Research, Melbourne, Australia

This paper presents the results of a blood group genetical survey carried out on 157 blood specimens from Melanesian Natives of four adjacent linguistic groups in the central region of New Britain, and the occasion of this report is taken to summarize existing blood group genetic data for the cultural and linguistic groups of the island of New Britain, and to compare these data with those of diverse peoples of the island of New Guinea.

This blood group survey was carried out as the result of an expedition to New Britain in 1956 for the purpose of starting child growth and development studies among primitive Melanesian tribal people. One of us (D.C.G.) collected several hundred blood specimens from native infants and children of various ages for the primary purpose of microbiological serological studies. The blood specimens were collected from unmixed representatives of the following ethnic-linguistic groups:

Kakuna Mamusi in the isolated highland interior of Central New Britain where this group lives with very little coastal contact either with the northern or southern shores. They number about 350 individuals and live in the villages of Pita, Morowana and Warali. Occasional marriages occur with Kisiluvi Mamusi, but none with other groups. These are a primitive people with perhaps the least contact with civilization of any group on the island until the last few years. Skull binding of the infants for the production of a cosmetic elongation deformation is still universally practiced among them. All blood specimens were collected in the village of Pita which is about 4,000 feet above sea level, above the Melkoi River gorge.

Kisiluvi Mamusi in the isolated highland interior of Central New Britain, just north of the closely related Kakuna Mamusi villages, and south of the coastal Central Nakanai groups. These people, also numbering about 350, have more contact with the coast, often visiting and now occasionally intermarrying with the Central Nakanai peoples. The Kisiluvi Mamusi villages of *Kisiluvi*, *Ligite*, *Kailona* and *Kilolo* have recently abandoned their traditional inland mountain village sites to settle at a lower altitude near the coast in the large Catholic social and communal settlement experiment at *Silanga*. The Kakuna and Kisiluvi Mamusi people appear to be distinct linguistically and in physical type from the coastal Nakanai peoples.

Central Nakanai from the north-central coast of New Britain directly east of the West Nakanai group. This term is an administrative designation for several linguistic groups with close cultural affinities who intermarry extensively. The Vere, Kaa and Wasi linguistic groups of the Central Nakanai were all included in the blood specimens from this region. These people are closely related cuturally and linguistically to the West Nakanai. In physical appearance they also resemble the West Nakanai.

West Nakanai from the north-central coast of New Britain on the Hoskins Peninsula east of Talasea. The West Nakanai number about 4,000. They are apparently not derived from peoples living in the interior. They occasionally marry a "bush" inhabitant, but such marriages are rare. Out-breeding, when it does occur, is customarily with other coastal people who are phenotypically indistinguishable from the West Nakanai. The language of the West Nakanai is referred to as Lakalai (fig. 1).

---

[1] The field work was carried out by one of us (D. C. G.) who was aided by a grant from the National Foundation for Infantile Paralysis Inc.

[2] Research Associate, University of California, Los Angeles; Consultant, Commonwealth Serum Laboratories, Melbourne.

[3] National Institute of Neurological Diseases and Blindness, National Institutes of Health, Bethesda, Maryland.

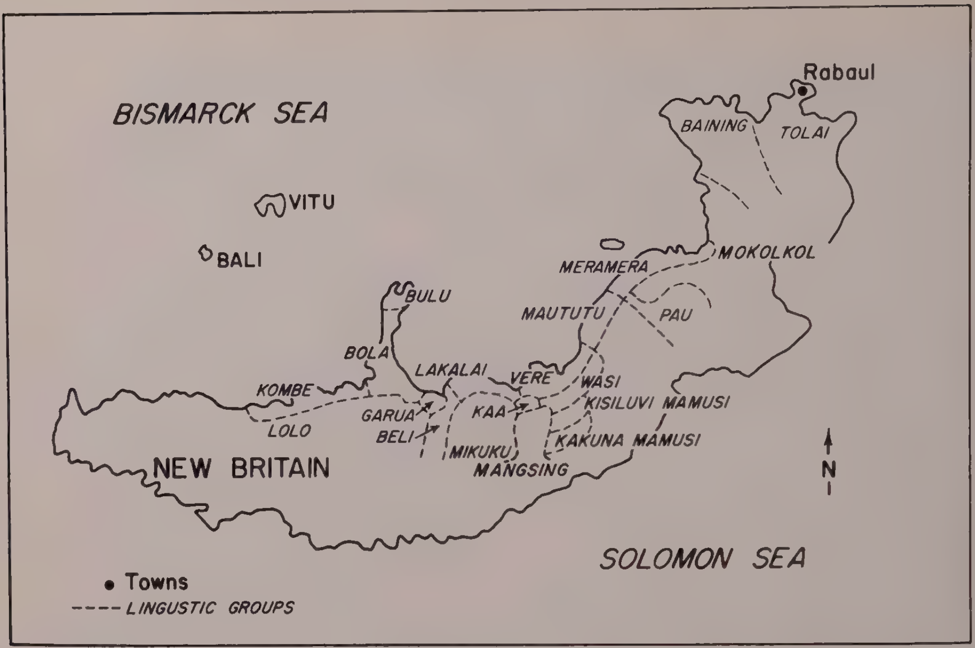


Fig. 1 Approximate location of linguistic and cultural groups of North-Central New Britain (adapted from Valentine, '58).

The West Nakanai were selected as a culturally and physically typical coastal Melanesian society for intensive ethnological and physical anthropological investigation (Valentine, '58; Swindler, '59), and the choice received confirmation from the blood group studies of Simmons et al. ('56).

The term "Nakanai" is applied to the peoples living on the northern coast of New Britain from, and including, the Hoskins Peninsula all the way eastward to the base of the Gazelle Peninsula, for it is properly a general term including all the closely related dialects from Lakalai east to, and including Meramera (Valentine, '58).

The locations of the various ethnic-linguistic groups are shown on the accompanying map (fig. 1).

The number of blood studies carried out on natives of New Britain has not been great. The first of these was an ABO survey on 753 natives at Rabaul by Heydon and Murphy ('23). Rabaul is situated in the extreme north of New Britain. Semple et al. ('56) reported their findings on 77 Bainings or Kaulongs, a race of primitive natives living in Malasaet Village in the interior of the Gazelle Peninsula of northeastern New Britain. They are thought to be the remnants of a population once widespread, who were driven into this refuge area on the arrival of the more highly developed Papuo-Melanesian populations such as the Tolais, who now inhabit the vicinity of Rabaul. Fostered by the Administration there has been a good deal of intermixture of the two groups, but there are still several Baining tribes little affected by Tolai influence. The Bainings are physically distinct from the coastal people, being rather shorter and more heavily built, with flat broad noses, prominent supraorbital ridges and forehead hair retreating as they approach middle age. Their cultural development is less complex. They are still partially nomadic with exceedingly primitive housing structures and no definite village organization Some anthropologists consider that they have relationships with the interior northern New Caledonians, the extinct Tasmanians and also with the highland populations of Central New Guinea.

The results of a blood genetical survey on 103 West Nakanai of New Britain were reported by Simmons, Graydon, Sempl and Swindler ('56). The investigation covered the ABO, MNS, Rh, P, Le^a, Fy^a and K blood group systems. P.T.C. taste tests were also carried out. The conclusions reached concerning the West Nakanai were that their blood group frequencies fall within the limits expected for Melanesia, and that confirmation was obtained for the earlier observation of Graydon and Simmons ('45) that the population of Melanesia is not genetically homogenous. In an extensive blood group study reported by Dunn, Kooptzoff, Price and Walsh ('56) a total of 1060 New Guinea natives resident near Port Moresby as members of the Pacific Islands Regiment were tested. This group contained 109 natives from New Britain but no information was given as to whether they represented a random sampling of New Britain, or had been recruited mainly from one area.

New Guinea. Graydon and Simmons ('45) and Simmons, Graydon, Woods, Smith and Lancaster ('46) demonstrated genetical heterogeneity in the Papuan coastal peoples in the ABO and MN blood groups, and the survey by Semple, Simmons, Graydon, Randmae and Jamieson ('56) added confirmation to that observation when differences were demonstrated between the Goroka natives and the people of Chimbu, Nondugl and Mount Hagen (Waghi Valley), a reasonably homogenous group. It may be said that in New Guinea there are moderate frequencies of A and B with high O, that subgroup A_2 is absent, m is low and n is very high, S of MNS is present but variable in percentage, while in the Rh system R^1 is extremely high, R^2 is low and R^0 is very low. The Rh negative gene r has not been demonstrated in the Melanesians or in the Pacific peoples generally. Semple et al. ('56) compiled tables showing the ABO, MN and Rh frequencies for New Guinea, and other Melanesian islands.

Graydon, Semple, Simmons and Franken ('58) in a paper relating to the pygmies of the Wissellakes of Netherlands, New Guinea collected the available blood group data for other Negrito peoples including those of Malaya, the Philippines and Andeman Islands. The gene frequencies were compared with those for natives of the Central Highlands of New Guinea, coastal Papuans, the Senoi of Malaya, aboriginal Malays, Filipinos, African pygmies of the Belgian Congo, and Negroes (Bantu) of Africa. It was shown that the gene frequencies of the separate pygmy groups are very different from each other, yet are similar to those of the tribes inhabiting nearby areas. It was inferred that the Papuan pygmies of the Wissellakes are true Papuan, not apparently related to the African pygmies, and that their relationship to other Asian pygmies is not close.

The results of the various blood surveys in New Britain are tabulated in the present paper. Earlier blood group data for Pacific peoples have been compiled in papers by Simmons and Graydon ('51) and by Simmons, Graydon and Semple ('53).

MATERIALS AND METHODS

Because of the nature of the pediatric and serological epidemiological problems for which the blood samples were collected, infant, child and adolescent populations were chosen rather than the adult population, which is usually selected for blood group genetic study. Specimens were obtained from the Kakuni Mamusi, Kisiluvi Mamusi, Central Nakanai and West Nakanai of New Britain. Random samples from each lot were used for blood group studies.

Sterile blood samples (20–30 ml) were collected from the antecubital vein in older children, and from the femoral vein in infants and younger children, and were allowed to clot. The specimens were kept without preservative, and were refrigerated when possible a few hours after collection at about 4°C until their arrival in Melbourne by air-freight. Red cells free from the clots were suspended in glucose-citrate blood preservative, and stored at 4°C. The methods employed in testing the blood samples have been described by Simmons, Graydon, Semple and Taylor ('51).

RESULTS AND DISCUSSION

The ABO blood groups

The ABO gene frequencies of the various surveys are given in table 1. The number of natives tested in each linguistic group in the present survey is small, even so, the Kakuna Mamusi, Kisiluvi Mamusi, Central Nakanai and West Nakanai are a reasonably homogenous group.

TABLE 1

ABO blood groups and gene frequencies in New Britain

Population	Authors	Number tested	Blood groups				Gene frequencies		
			O	A_1	B	A_1B	*A*	*B*	*O*
Kakuna Mamusi	Present survey	45	25	9	9	2	0.13	0.13	0.74
Kisiluvi Mamusi	Present survey	27	19	5	2	1	0.12	0.06	0.82
Central Nakanai	Present survey	25	14	3	7	1	0.08	0.18	0.74
West Nakanai	Present survey	60	24	13	21	2	0.13	0.22	0.64
West Nakanai[1]	Simmons, Graydon, Semple and Swindler ('56)	103	48 46.6%	17 16.5%	35 34%	3 2.9%	0.103	0.206	0.691
Totals		260	130 50%	47 18.1%	74 28.5%	9 3.5%	0.115	0.177	0.708
Rabaul natives[1]	Heydon and Murphy ('23)	753	404 53.7%	202 26.8%	123 16.3%	24 3.2%	0.164	0.104	0.733
Bainings	Semple, Simmons, Graydon, Randmae and Jamieson ('56)	77	16 21.0%	27 35.0%	22 29.0%	12 16.0%	0.297	0.252	0.451
Unclassified natives	Dunn, Kooptzoff, Price and Walsh ('56)	109	69 63.3%	20 18.3%	16 14.7%	4 3.7%	0.109	0.088	0.803

[1] The subgroups of A were not determined in these surveys.

TABLE 2

MN types and gene frequencies in New Britain

Population	Authors	Number tested	M–N types			Gene frequencies	
			M	MN	N	*m*	*n*
Kakuna Mamusi	Present survey	45	7	11	27	0.28	0.72
Kisiluvi Mamusi	Present survey	27	2	11	14	0.28	0.72
Central Nakanai	Present survey	25	1	6	18	0.16	0.84
West Nakanai	Present survey	60	2	17	41	0.17(5)	0.82(5)
West Nakanai	Simmons et al. ('56)	103	3 2.9%	41 39.8%	59 57.3%	0.228	0.772
Totals		260	15 5.8%	86 33.1%	159 61.2%	0.223	0.777
Bainings	Semple et al. ('56)	77	0	0	77	0	1.000
Unclassified natives	Dunn et al. ('56)	109	4 3.7%	35 32.2%	70 64.2%	0.198	0.802

The unclassified natives of Dunn et al. ('56) are again similar except that B is 0.088 compared with 0.177 for the four groups. The Rabaul natives of Heydon and Murphy ('23) show particularly an increase of A (0.164 compared with the average of 0.115). The increase in A in the northern area of New Britain is also seen in the 77 Bainings whose A is 0.297, and who also possess the highest B found in New Britain—0.252. All members of groups A and AB were of subgroup A_1.

The MN types

The MN frequencies are presented in table 2. The Kakuna Mamusi and Kisiluvi Mamusi show identical frequencies, while the Central and West Nakanai show a higher n frequency than the above. The n frequency is also high in the unclassified natives, while in the Bainings n is 1.000, that is all of the 77 samples tested were of type N.

The Rh types

In table 3 the Rh gene frequencies are given. Three genes R^1, R^2 and R^0 are enough to account for the phenotypes found in all the surveys except in the unclassified natives of Dunn et al. ('56), where one unconfirmed example of $\mathrm{Rh}_1\,\mathrm{Rh}_z$ was found. The presence of the extremely rare examples of R^z may be accounted for by recent introduction in New Guinea from Australian aborigines by exchange of visits (Simmons et al., '56 and '58), or as gene introduced by Mongoloids either in New Britain or in New Guinea. Only 4 examples have been found in New Guinea and one in New Britain, and three of the former were found at Daru Island a point of contact with Australian aborigines via Cape York Peninsula. Australian aborigines are rich in the gene R^z. The outstanding Rh feature common in Melanesia is the high R^1 frequency, and this also applies in New Britain. The average frequency for the four native groups previously mentioned for R^1 is 0.931, and both R^1 and R^2 frequencies are similar in the four groups. In the smaller groups, Kakuna Mamusi, Kisiluvi Mamusi and Central Nakanai, the phenotype $\mathrm{Rh}_1\,\mathrm{Rh}_0$ indicating the presence of the gene R^0 was not detected. The West Nakanai (60 and 94), the Bainings (77) and the unclassified

TABLE 3

Rh types and gene frequencies in New Britain

Population	Authors	Number tested	Rh types					Gene frequencies			
			$\mathrm{Rh}_1\mathrm{Rh}_1$	$\mathrm{Rh}_1\mathrm{Rh}_0$	Rh_2	$\mathrm{Rh}_1\mathrm{Rh}_2$	$\mathrm{Rh}_1\mathrm{Rh}_z$	R^1	R^2	R^0	R^z
Kakuna Mamusi	Present survey	40	38	0	0	2	0	0.97(5)	0.02(5)	0	0
Kisiluvi Mamusi	Present survey	27	23	0	0	4	0	0.93	0.07	0	0
Central Nakanai	Present survey	25	21	0	1	3	0	0.90	0.10	0	0
West Nakanai	Present survey	60	54	3	0	3	0	0.95	0.02(5)	0.02(5)	0
West Nakanai	Simmons et al. ('56)	94	78 83%	9 10%	1 1%	6 6%	0	0.910	0.039	0.051	0
Totals		246	214 87.0%	12 4.9%	2 0.7%	18 7.3%	0	0.931	0.042	0.027	0
Bainings	Semple et al. ('56)	77	51 66%	2 3%	2 3%	22 29%	0	0.818	0.168	0.014	0
Unclassified	Dunn et al. ('56)	109	78 71.6%	5 4.6%	2 1.8%	23 21.1%	1 0.9%	0.846	0.122	0.027	0.006

natives (109) all showed the gene R^0. In the unclassified group the frequency for R^1 was only 0.846 compared with the average of the four central New Britain groups of 0.931, and in the Bainings it was 0.818 with a corresponding increase in the R^2 frequency to 0.168.

Rh_0 (D^u) variants

In a previous survey in West Nakanai, Simmons et al. ('56) reported that they had found 8 of 94 blood samples which contained "low-grade" Rh_0 (D^u) variants. The finding was unusual amongst the Pacific peoples, although "high-grade" and "low-grade" Rh_0 (D^u) variants are found in Australian aborigines. In the present survey 9 of 157 blood samples showed variants and these were all "high-grade." The distribution was 1/45 Kakuna Mamusi, 3/27 Kisiluvi Mamusi, 0/25 Central Nakanai and 5/60 West Nakanai. The proportion of variants is about the same in both West Nakanai surveys, however, in the first series the variants were all "low-rade" while in the present series all were "high-grade." The difference may be real, or it may be due to the quality of the red cells at the time of testing or to the fact that different potent agglutinating anti-Rh_0 (D) sera were used in testing the two series. The natives of New Britain therefore differ from most Melanesians in possessing a high proportion of Rh_0 (D^u) variants particiularly in the native groups in the central area of the island.

The blood groups Duffy (Fy^a) and Diego (Di^a)

Table 4 shows the numbers tested in the various tribal groups for the Duffy and Diego blood groups. All of 132 natives were Fy(a+), and none of 97 were Di(a+).

Blood groups in New Britain and New Guinea

The results of surveys in New Britain are compared with selected representative surveys in New Guinea (table 5). A later paper will discuss more fully the blood group gene frequencies found in New Guinea in various surveys reported to date. In table 6 the maximum-minimum variation for natives in New Britain and New Guinea are compared for *A*, *B*, *O*, *m*, *n*, R^1, R^2 and R^0 gene frequencies. The same basic pattern of high *O*, high *n* and high R^1 is followed in both New Britain and New Guinea, and when the range of variation for each gene frequency is tabulated, the pattern is again similiar for both islands. It would seem that the same basic stock is present in both New Britain and New Guinea, and while natives of different linguistic groups in particular areas in each island appear to be homogenous in their blood picture, the over-all pattern in both islands is one of genetical heterogeneity.

SUMMARY

Blood samples from native children of the central area of New Britain namely, Kakuna Mamusi, Kisiluvi Mamusi, Central Nakanai and West Nakanai have been tested for the ABO, MN, Rh, Duffy (Fy^a) and Diego (Di^a) blood groups.

The calculated blood group gene frequencies have been compiled for the various surveys in New Britain, and comparisons have been made with the results of representative surveys published for the divisions of New Guinea, Papua and Dutch New Guinea.

While natives of different linguistic groups of certain areas appear to be homogenous in terms of gene frequencies, the overall pattern for New Britain and New

TABLE 4

Duffy (Fy^a) and Diego (Di^a) blood groups in New Britain

Population	Authors	Fy(a+)	Di(a+)
Kakuna Mamusi	Present survey	19/19	0/37
Kisiluvi Mamusi	Present survey	15/15	0/17
Central Nakanai	Present survey	14/14	0/19
West Nakanai	Present survey	16/16	0/24
West Nakanai	Simmons et al. ('56)	46/46	—
Bainings	Semple et al. ('56)	22/22	—
Totals		132/132 100%	0/97 0%

TABLE 5

Gene frequencies in New Britain and New Guinea

Population	Authors	Number tested	Gene frequencies								
			A	*B*	*O*	*m*	*n*	R^1	R^2	R^0	R^z
New Britain (central)	Present survey	260	0.115	0.177	0.708	0.233	0.777	0.931	0.042	0.027	0
Rabaul natives (north)	Heydon and Murphy ('23)	753	0.164	0.104	0.733	—	—	—	—	—	—
Bainings (north)	Semple et al. ('56)	77	0.297	0.252	0.451	0	1.000	0.818	0.168	0.014	0
Unclassified	Dunn et al. ('56)	109	0.109	0.088	0.803	0.198	0.802	0.846	0.122	0.027	0.006
New Guinea											
Papua coastal	Simmons et al. ('46)	455	0.197	0.160	0.642	0.133	0.867	0.945	0.020	0.020	0.015[1]
New Guinea Central Highlands	Semple et al. ('56)	485	0.195	0.159	0.646	0.036	0.964	0.892	0.081	0.028	0
Central Highlands Goroka	Semple et al. ('56)	123	0.168	0.102	0.729	0.081	0.919	0.801	0.129	0.071	0
New Guinea and Papua	Dunn et al. ('56)	1060	0.219	0.133	0.648	0.167	0.834	0.907	0.066	0.026	0.001
New Guinea Western Highlands	Macintosh et al. ('58)	2690	0.240	0.120	0.641	0.053	0.947	0.932	0.048	0.020	0
Dutch New Guinea Pygmies	Graydon et al. ('58)	139	0.075	0.139	0.783	0.102	0.898	0.850	0.119	0.030	0

[1] Probably introduced from the Cape York Australian aborigines (Simmons et al. ('56 and '58) to Daru Island.

TABLE 6

Variation of blood group frequencies in New Britain and New Guinea

Population	*A*	*B*	*O*	*m*	*n*	R^1	R^2	R^0
New Britain	0.109–0.297	0.088–0.252	0.451–0.803	0 –0.233	0.777–1.0	0.818–0.931	0.042–0.168	0.014–0.027
New Guinea	0.075–0.240	0.102–0.160	0.641–0.783	0.036–0.167	0.834–0.964	0.801–0.945	0.020–0.129	0.020–0.071

Guinea is one of genetical heterogeneity. The same basic pattern of high O, high n and high R^1 is followed in both New Britain and New Guinea.

ACKNOWLEDGMENTS

The authors acknowledge with gratitude the field assistance of Drs. K. Pike and W. Smythe, and anthropologists Mr. and Mrs. C. A. Valentine. Miss V. M. Casey gave technical assistance in the laboratory, and Dr. J. J. Graydon of the Commonwealth Serum Laboratories kindly calculated the blood group gene frequencies for the survey.

LITERATURE CITED

Dunn, D., O. Kooptzoff, A. V. G. Price and R. J. Walsh 1956 The blood groups of a third series of New Guinea natives from Port Moresby. Oceania, *27:* 56–63.

Graydon, J. J., and R. T. Simmons 1945 Blood groups in the Territory of Papua. Med. J. Austr., *2:* 77–80.

Graydon, J. J., N. M. Semple, R. T. Simmons and S. Franken 1958 Blood groups in pygmies of the Wissellakes in Netherlands New Guinea with anthropological notes by H. J. T. Bijlmer. Am. J. Phys. Anthrop., *16:* 149–172.

Heydon, G. M., and T. W. Murphy 1923 Biochemical index in natives of the Territory of New Guinea, (Rabaul). Med. J. Austr. *2:* 617.

Macintosh, N. W. G., R. J. Walsh and O. Kooptzoff 1958 The blood groups of the native inhabitants of the western highlands of New Guinea. Oceania, *28:* 173–198.

Semple, N. M., R. T. Simmons, J. J. Graydon, G. Randmae and D. Jamieson 1956 Blood group frequencies in natives of the central highlands of New Guinea and in the Bainings of New Britain. Med. J. Austr. *2:* 365–371.

Simmons, R. T., and J. J. Graydon 1951 A comparison of the blood groups, subgroups, MN and Rh types found in Java with those found in other parts of Indonesia, together with a summary of the evidence for north-south gradients in the values for the blood gene q, m, and R^1. Ibid., *1:* 173–179.

Simmons, R. T., J. J. Graydon and D. C. Gajdusek 1958 A blood group genetical survey in Australian aboriginal children of the Cape York Peninsula. Am. J. Phys. Anthrop., *16:* 59–78.

Simmons, R. T., J. J. Graydon and N. M. Semple 1953 A further blood genetical survey in Micronesia; Palauans, Trukese and Kapingas. Med. J. Austr., *2:* 589–596.

Simmons, R. T., J. J. Graydon, N. M. Semple and D. R. Swindler 1956 A blood group genetical survey in West Nakanai, New Britain. Am. J. Phys Anthrop., *14:* 275–286.

Simmons, R. T., J. J. Graydon, N. M. Semple and C. N. D. Taylor 1951 Blood, taste and secretion: a genetical survey in Maoris. Med. J. Austr., *1:* 425–431.

Simmons, R. T., J. J. Graydon, E. F. Woods, W. A. H. Smith and H. O. Lancaster 1946 Further observations on the Rh and Hr factors, and the blood group frequencies in Papuans. Ibid., *1:* 537–539.

Swindler, D. R. 1959 A racial study of the West Nakanai of New Britain. University of Pennsylvania monograph, in press.

Valentine, C. A. 1958 An introduction to the history of changing ways of life on the island of New Britain. Dissertation to Faculty of Graduate School of University of Pennsylvania.

Blood Groups of the Penobscot Indians[1]

FRED H. ALLEN, JR., AND PATRICIA A. CORCORAN
Blood Grouping Laboratory, Boston, Massachusetts, and the Department of Pediatrics, Harvard Medical School

A number of recent studies have been made of the blood groups of indigenous Americans in Western Canada, Western United States, and Western South America. These studies have included most or all of the 9 well-established blood group systems, and those done since 1956 have used anti-Di^a which identifies a blood group factor that is very rare in populations of European origin and fairly common in Eastern Asians and American Indians. Very little testing has been done on the blood groups of Indians of the Eastern seaboard, the only published data being on the ABO groups of 279 Micmac Indians in New Brunswick (Gates, '38). The Micmacs were 62% group O, 33% group A, 4% group B, and 1% group AB. Gates thought at the time that the high percentage of group O meant that the Micmacs had originally all been of group O. Boyd later demonstrated mathematically ('39) that the American Indians must have had some group A before the coming of the Europeans. We are reporting extensive blood grouping tests of 249 Penobscot Indians, done in 1958.

One of the reasons that little blood grouping work has been done on the Indians of the East coast is that these people have been in close contact with whites for over 300 years and there have been many intermarriages. Thus it was known that none of the Eastern tribes was representative of pure Indian stock, and the pioneer investigators of blood groups in Indians went West to find the purer stocks. The testing that has been done on Western Indians in recent years, especially by Chown and Lewis ('53, '55) has shown that certain blood group factors (especially K and Le^a) which are fairly common in whites, are apparently absent in full-blooded Indians. These, added to A_2 and B, previously known to be rare to absent in full-blooded Indians (Wiener, '43) make 4 factors that serve as indicators of purity of the stock. The gene r also is useful in this connection since its frequency is so low in pure Indian stocks and so high in whites.

We were interested not only in the blood types per se, but also in investigating the inheritance of blood factor Di^a, first reported by Levine et al. ('54) and extensively studied by Layrisse, Arends, and Dominguez Sisco (cf. Layrisse, '58). Family studies on Di^a are still incomplete, and we hoped to get linkage data. Therefore, families were sought especially, and some effort was made to get a missing individual in a family. For this reason, the whole series has more related people than would have been the case otherwise. Also, since we were particularly interested in families in which the factor Di^a occurred, we made special efforts to get such families complete. Consequently, the entire group being reported has an incidence of Di(a+) that is slightly exaggerated. Everyone in the Penobscot tribe living in or near Old Town was directly invited to participate, and none was turned away.

Blood group factors of European origin were minimized by eliminating from the count any who have too little Indian ancestry to be included in the official tribal cenus. Also a highly selected subgroup was chosen for separate analysis by eliminating any who were related as closely as first cousin, and choosing the individual of an older generation when there was a choice. Choice between related people of the same generation was done by lot. The entire group, after elimination of those not shown in the official census, numbered 249, while the selected group of persons

---

[1] Supported by grant H-2405, National Institutes of Health. Presented in part at the Xth International Congress of Genetics, Montreal, 1958.

not closely related consisted of 72 persons. All or nearly all have some European ancestry, though a great many believe they are ¾ Indian or more. So far as is known, all the genes are of European or Indian origin. Mr. and Mrs. Bruce Poolaw, Mrs. Susie Dana, Mrs. Edwin Mitchell, and Mrs. Ruth Davis of the Penobscot tribe were most patiently helpful in working out the pedigrees and in rounding up volunteers. Samples were collected in 5 separate trips to Old Town, Maine, kept under refrigeration in large thermos jugs, and brought back to Boston for testing.

Reagents used are listed in table 1. Thirty-two different reagents were used, and most bloods were tested with 26 of these. (Anti-k was used only to test K-positives. Anti-Js became available only very late in the investigation.) All these antibodies and their corresponding antigens are described in the Third Edition of Race and Sanger ('58). We are most grateful to a number of our colleagues listed in the table, for gifts of serum.

TABLE 1

Reagents used in tests of Penobscots

Reagent	Lot No.	Source
Anti-A	SA 37	BGL
Anti-B	SB 116	BGL
Anti-A_1	SAA 56	BGL
Anti-H	ulex ext.	BGL
Anti-C(rh′)	SRC 77	BGL
Anti-D(Rh_o)	ARD 67	BGL
Anti-E(rh″)	ARE 117	BGL
Anti-c(hr′)	AHC 67	BGL
Anti-e(hr″)	AHE 62	BGL
Anti-C^w(rh^{w1})	ARCW 67	BGL
Anti-E^w(rh^{w2})		T. Greenwalt
Anti-M	SM 46	BGL
Anti-N		Hyland
Anti-S	Fa237	R. E. Rosenfield
Anti-M^g	8259	BGL
Anti-Mi^a	UB4	J. F. Mohn
Anti-Vw	SVW 58	BGL
Anti-P	Sal.	BGL
Anti-Le^a	SLEA 47	BGL
Anti-Le^b	SLEB 47	BGL
Anti-Lu^a	Mar.	R. E. Rosenfield
Anti-K	CK 117	BGL
Anti-k	M.N.	P. Schmidt
Anti-Kp^a	CKPA 97B	BGL
Anti-Kp^b	CKPB 48	BGL
Anti-Fy^a	CFYA 97A	BGL
Anti-Jk^a	McC.	BGL
Anti-Jk^a	CJKA 48	BGL
Anti-Di^a	Woj.	J. F. Mohn
Anti-Di^a		M. Layrisse
Anti-Wr^a	SWRA18B	BGL
Anti-Be^a		K. Stern
Anti-Vel	Vande	J. J. van Loghem
Anti-Js	Ro.	R. E. Rosenfield

RESULTS

There is considerable variety in the blood types found. One hundred and seventy-five different phenotypes were seen, as indicated in table 2, of which 130 were found only once. It is of some interest that even in such a small population there were two groups of 6 identical phenotypes, indicating that the commonest phenotypes are not at all rare. Some of the variability is clearly the result of European genes, but much is not, and it is a fascinating, though quite unproductive pastime (so far) to speculate on the possible significance of the degree of variability within a population.

TABLE 2

Variety of types found among 249 Penobscots

Unique	130
2 alike	31
3 alike	6
4 alike	3
5 alike	3
6 alike	2[1]
Total	175 different phenotypes

[1] One of these sets of 6 were all 0, MNS, the other 6 were all A, MNs. All of these 12 were Rh_1rh, Fy(a+), Jk(a+), P+.

Table 3 shows the ABO groups, and, as in subsequent tables, the frequencies are given both for the total group and for the selected group of 72 persons not closely related. The selected group has a higher frequency of gene A_1 and a lower frequency of A_2. It is probable that A_1 was a common gene in American aboriginals as previously stated, but that A_2 was rare or possibly absent. B may well have been absent before the arrival of the Europeans. The frequency for gene O is not very different from that seen in European populations.

The MNS types are shown in table 4. *M* was high, especially in the selected group, though not as high as has been found in many other Indian groups. *S* has a fairly high frequency, but it has been found fairly common in all Indian groups. The antigens M^g, Vw, and Mi^a, so rare in

TABLE 3

ABO blood groups of Penobscots

		Total group		72 not closely related	
		Number	Frequency	Number	Frequency
Phenotypes:	O	133	0.53	33	0.46
	A_1	100	0.40	35	0.49
	A_2	15	0.060	3	0.042
	A_1B	1	0.0040	1	0.014
Genes:	O		0.73		0.68
	A_1		0.23		0.29
	A_2		0.040		0.030
	B		0.0020		0.007

TABLE 4

MNS blood groups of Penobscots[1]

		Total group		72 not closely related	
		Number	Frequency	Number	Frequency
Phenotypes:	M,S−	36	0.1446	8	0.1112
	M,S+	63	0.2530	21	0.2916
	MN,S−	60	0.2409	14	0.1944
	MN,S+	60	0.2409	23	0.3193
	N,S−	19	0.0763	3	0.0417
	N,S+	11	0.0442	3	0.0417
Genes:	M	$318/498 =$	0.6386	$95/144 =$	0.6597
	N	$180/498 =$	0.3614	$49/144 =$	0.3403
	S	$1-\sqrt{0.4618} =$	0.3204	$1-\sqrt{0.3473} =$	0.4107
	Ms	$\sqrt{0.1446} =$	0.3803	$\sqrt{0.1112} =$	0.3335
	MS	$M-Ms =$	0.2583		0.3262
	NS	$S-MS =$	0.0621		0.0845
	Ns	$N-NS =$	0.2993		0.2558

[1] All 249 bloods were M^g-negative, Vw-negative. All of 99 tested were Mi(a−).

TABLE 5

Rh blood groups of Penobscots[1]

		Total group		72 not closely related	
		Number	Frequency	Number	Frequency
Phenotypes:	rh	22	0.0884	3	0.0417
	Rh_1rh	83	0.3333	18	0.2500
	Rh_1Rh_1	58	0.2329	21	0.2916
	Rh_1Rh_2	60	0.2410	17	0.2361
	Rh_2Rh_2	12	0.0482	5	0.0695
	Rh_2rh	14	0.0562	8	0.1112
Genes:	r		0.2831		0.2222
	R^1		0.5201		0.5347
	R^2		0.1968		0.2431

[1] All 249 bloods were C^w-negative, E^w-negative. One blood of phenotype Rh_1rh was a D^u variant. Gene frequencies were calculated by direct count.

Europeans, appear to be rare also in the Indians.

The Rh groups (table 5) are what would be expected from previous work on the Western tribes except for the apparent bsence of gene R^z, which is not at all are in the Indians of Western Canada (Chown and Lewis, '53, '55) and the rather high frequency of r.

The low frequency of K and Kp^a (table 6) is like that seen in Western Indians, and as expected most are Lewis (a-b+) (table 7). Of interest in table 8 is the rather low incidence of P+ in comparison

TABLE 6

Kell blood groups of Penobscots

		Total group		72 not closely related	
		Number	Frequency	Number	Frequency
Phenotypes:	K+k+Kp(a−b+)	1	0.0040	0	0.0000
	K−,Kp(a+b+)	4	0.0161	2	0.0278
	K−,Kp(a−b+)	244	0.9799	70	0.9722
Genes:	$K^b(KKp^b)$		0.002		0.000
	$k^a(kKp^a)$		0.008		0.014
	$k^b(kKp^b)$		0.99		0.986

TABLE 7

Lewis blood groups of Penobscots

	Total group		72 not closely related	
	Number	Frequency	Number	Frequency
Le(a+b−)	9	0.036	1	0.014
Le(a−b+)	234	0.94	70	0.972
Le(a−b−)	6	0.024	1	0.014

TABLE 8

Other blood groups of Penobscots

Number tested	Phenotypes	Number	Phenotype frequencies	Genes	Gene frequencies
249	P+	194	0.78	*P*	0.53
249	Lu(a+)	21	0.084	Lu^a	0.043
249	Fy(a+	196	0.79	Fy^a	0.54
249	Jk(a+)	201	0.81	Jk^a	0.56
249	Di(a+)	20	0.080	Di^a	0.041
249	Wr(a+)	0	0	Wr^a	0
249	Be(a+)	0	0	Be^a	0
133	Vel+	133	1.000	*Vel*	1.00
7	Js+	0	0	*Js*	0
72[1]	P+	61	0.8472	*P*	0.61
72	Lu(a+)	4	0.0555	Lu^a	0.028
72	Fy(a+)	58	0.8066	Fy^a	0.56
72	Jk(a+)	61	0.8472	Jk^a	0.61
72	Di(a+)	4	0.0555	Di^a	0.028

[1] 72 "not closely related."

with European populations, again similar to Western Indians. Lutheran (Lu^a) positive was apparently quite common in the whole group, but exactly ⅓ of the *Lu*^{a} genes came from a single known white ancestor. Duffy (Fy^a) positive is less frequent than in previous Indian groups tested, but still higher than in Europeans. Wr^a, Be^a, and Js, rare in Europeans, are rare or absent in the Penobscots, and, similar to Europeans, Vel+ is universal, though two siblings were such weak positives that they were at first thought to be negative.

On the basis of the selected group of 7 not closely related, Di^a has a lower fr quency than in any of the America aboriginal groups reported, except f Eskimos (Lewis and Chown, '56).

Linkage scores on Diego are shown i table 9. We obtained a disappointing small amount of information, and th question of the possible relation of Di^a one of the 9 established blood-group sy tems is still not settled. Our results co firmed the lack of relationship between D and the ABO, Rh, and MNS systems, b there was one family in which a linka

TABLE 9
Linkage scores vs. Diego gene Di^a

Systems	(λ)	(k)	Recombinations
ABO	0	2	1
Rh	+3	5	1
MNS	+1	7	2
Lutheran	+3	3	0

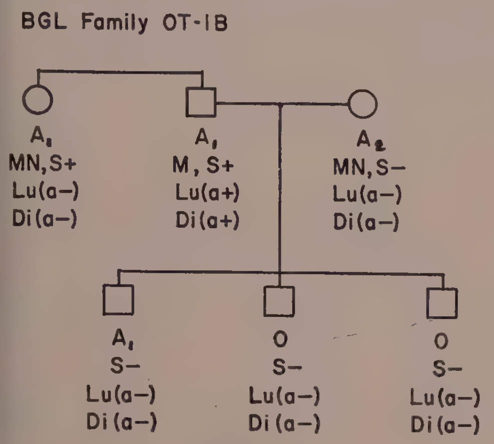


Figure 1

count between Di^a and Lu^a was possible. This is the first such family found to our knowledge, and it is consistent with a very tentative hypothesis that Di^a may be in the Lutheran family, though the matter is very far from proven. The serologic behavior of anti-Di^a is quite dissimilar to that of anti-Lu^a for whatever that is worth: anti-Di^a requires the Coombs test while anti-Lu^a is a "saline" agglutinin. The family which gave the linkage count Di^a vs. Lu^a is shown in figure 1. All the relevant data from this family are shown, and it can be seen that these data support the hypothesis that Di^a is in the MNS system just as well as that it is in the Lutheran system. However, non-linkage to the MNS system has been adequately shown by other investigations, including those shown in table 9, while there are no other data for or against possible linkage to Lutheran (cf. Layrisse et al., '59).

DISCUSSION

The blood groups of the Penobscots are strikingly similar to other American Indian groups that have been tested. Most important in this similarity is the frequency of Di^a, which is lower than in some Indian groups but differentiates them clearly from any European population. The very low incidence of factors B and K, and the high frequency of M, E (rh″), Le^b, and Fy^a also are characteristic of Indian and uncharacteristic of European populations. There are many European genes in the population, however, and these are reflected in the relatively high frequency, for Indians, of the factor A$_2$. One wonders a little why A$_2$ should be so high while B and K are so low; presumably, however, these low-frequency factors have a much greater chance of relatively large changes in frequency due to chance (genetic drift).

The percentage of European genes can be estimated very roughly by assuming that a pure Indian population would have no r genes. Taking r for Europeans as 0.40, a population consisting of 55% European genes and 45% Indian would have the frequency (0.22) for r observed in the Penobscots. This appears to be a reasonable estimate when the figure 55% is used to calculate from the Penobscot data the aboriginal gene frequencies for Fy^a and N, which (on the basis of $Fy^a = 0.414$ and $N = 0.470$ in Europeans) turn out to be about 0.74 for Fy^a and 0.18 for N. It is by no means certain that the original premise is correct that r would be absent in a pure Indian population, but it is very probable on the basis of the other studies referred to, and still others not yet reported (Steinberg; Chown and Lewis; Allen and Newman) that r was very infrequent in the original Indian populations, and may well have been absent.

The high frequency of r among the Penobscots makes it possible to say that the Rh genes r', r'', r^y, and R^o are all rare to absent. In a population with no r genes, a good many of the other above-mentioned genes can be present but undetected. It is quite unlikely that the combined frequency of all these genes is as high as 2% in the Penobscots. None was directly demonstrable.

The linkage counting is difficult in some respects in a pure Indian population because of the rarity of K+, Lu(a+), and Fy(a−). It was hoped at the beginning of this study that enough white K, Lu^a, and Fy^b genes would be found in the Penobscots to allow linkage counts with Di^a. Unluckily, very few data of this type were obtained as was shown in table 9.

SUMMARY

Extensive blood grouping tests on 249 Penobscot Indians from Old Town, Maine, are reported. With allowance for an estimated 55% white admixture, the Penobscots have the typical blood group characteristics that have been shown in American Indians from Western, North and South America. The white admixture was useful in analyzing the Rh types, and could have been very helpful, though by bad luck it was not, in searching for possible blood-group linkages with the factor Di^a. One count was possible between Di^a and Lu^a, and is the first to be reported. Certain blood group factors that are rare in whites are rare or absent also in the Penobscots.

LITERATURE CITED

Boyd, W. C. 1939 Blood groups of American Indians. Am. J. Phys. Anthrop., *25:* 215–235.

Chown, B., and M. Lewis 1953 The ABO MNSs, P, Rh, Lutheran, Kell, Lewis, Duffy, and Kidd blood groups and the secretor status of the Blackfoot Indians of Alberta, Canada. Ibid. *11:* 369–384.

——— 1955a The inheritance of the blood group and secretor genes in the BLOOD Indians of Alberta, Canada. Ibid., *13:* 473–478.

——— 1955b The blood group and the secretor status of the Stoney and Sarcee Indians of Alberta, Canada. Ibid., *13:* 181–190.

Gates, R. R. 1938 The blood groups and further features of the Micmac Indians. J. Roy Anthrop. Inst., *68:* 288–298.

Layrisse, M. 1958 Anthropological considerations of the Diego (Di^a) antigen. Am. J. Phys Anthrop., *16:* 173–186.

Layrisse, M., R. Sanger and R. R. Race 1959 The inheritance of the antigen Di^a: evidence for its independence of other blood group systems. Am. J. Human Genetics, *11:* 17–25.

Levine, P., E. A. Koch, R. T. McGee and G. H Hill 1954 Rare human isoagglutinins and their identification. Am. J. Clin. Path., *24:* 292

Lewis, M., B. Chown and H. Kaita 1956 Further observations on the blood factor Di^a. Nature, *178:* 1125.

Race, R. R., and R. Sanger 1958 Blood Groups in Man. Blackwell, London, 3rd edition, 377 pp

Wiener, A. S. 1943 Blood Groups and Transfusion. C. C Thomas, 3rd edition, 438 pages (p. 323).

Distribution of Hereditary Blood Factors Among Koreans Residing in Seoul, Korea

CHONG DUK WON, HAN SU SHIN, SUK WHAN KIM
JANE SWANSON AND G. ALBIN MATSON
Korean Red Cross Blood Bank, Seoul, Korea Department of Obstetrics and Gynecology, Seoul National University Hospital, Seoul, Korea and the Minneapolis War Memorial Blood Bank, Minneapolis, Minnesota, U. S. A.

The distribution of the hereditary blood factors among Koreans has not been reported since many of the "newer" factors have been discovered. In 1924, Kirihara ('24) reported on the distribution of the ABO groups in 354 Koreans at Heihoku, Furuhata in 1933, reported on the cumulative data of the studies of all investigators up to that time which totaled 9,434 persons and Sarkisian in 1956, reported on 1,000 South Koreans north of Seoul which were tested for the ABO groups. The reported observations of these workers are shown on table 1.

Yamamato ('43) studied the incidence of the MN types among Koreans (table 5). Little or no additional work has been reported, however, on the incidence of hereditary blood factors among this people.

An opportunity was afforded us to test blood specimens of Koreans living in Seoul.

MATERIAL AND METHODS

Specimens were obtained at random from volunteers at the Korean Red Cross Blood Bank at Seoul and from patients at the Department of Obstetrics and Gynecology, National Hospital at Seoul and tested in these laboratories for ABO, M-N and Rh types. Duplicate specimens (approximately 5 cm^3) were taken by venipuncture and deposited in sterile numbered tubes. They were refrigerated immediately and then the clotted specimens were sent as soon as possible via Air Mail to the laboratories of the Minneapolis War Memorial Blood Bank. For the most part the bloods arrived in suitable condition for testing but a few specimens were so hemolyzed that it was considered better to exclude them from our tests.

Upon arrival at the Minneapolis laboratory the blood samples were put at once in a refrigerator at 4–6°C and the sera and clots were separated. Cells from clots were washed with 0.9% saline solution and tested with suitable antisera for antigens A, B, M, N, C, D, E, c, e, P_1, K, Fy^a, Le^a and Di^a.

RESULTS AND DISCUSSION

The results of the tests on the blood specimens are listed on the tables under the various blood group systems. The calculation of the gene frequencies in all the tables have been calculated from the phenotype data by Whitney L. Johnson, Department of Mathematics, Institute of Technology, University of Minnesota, using the recognized formulae outlined by Mourant ('54).

ABO blood groups

The results of the ABO grouping tests done on 322 Koreans are shown on table 1.

From the table it is seen that in this study the results of tests for antigens in the ABO blood group system agree favorably with the percentage data reported for Koreans by other workers (Kirihara, '24; Furuhata, '33; Sarkisian, '56). Of 322 bloods selected at random, 103 or 31.99% were group O, 100 or 31.06% were A_1, 93 or 28.88% were B and 26 or 8.07% were A_1B. No A_2 or A_2B were found.

Perhaps the most noteworthy observation from table 1 is the high frequency of the B gene. The value of 20.69% for q, the frequency of the B gene, among Koreans agrees well with the high gene frequencies of B in other Asiatic peoples. In Central Asia and Northern India there ap-

TABLE 1

ABO grouping tests on 322 Koreans in Seoul—other reports for comparison

Peoples	Number tested	Number and per cent of phenotypes								Per cent gene frequencies			Sum of gene frequencies
		O		A		B		AB					
		No.	%	No.	%	No.	%	No.	%	p	q	r	p + q + r
Koreans[1] (this study)	322	103	31.99	100	31.06	93	28.88	26	8.07	22.08	20.69	57.23	100.00
Koreans (Kirihara, '24)	354	108	30.51	97	27.40	122	34.46	27	7.63	19.62	24.18	56.20	100.00
Koreans (Furuhata, '33)	9434	2614	27.71	2972	31.50	2898	30.72	950	10.07	23.65	23.14	53.21	100.00
Koreans (Sarkisian, '56)	1000	270	27.00	320	32.00	290	29.00	120	12.00	25.13	23.15	51.72	100.00
Minnesota Whites (Matson, '54)	300	120	40.00	137	45.67	35	11.67	8	2.66	29.00	8.50	62.50	100.00

[1] Although all were tested for A_2 none was found.

pears a well-marked maximum frequency of B. In peoples of Europe, on the other hand, the B gene diminishes in frequency from East to West so that in parts of Holland, France, Spain and Portugal the frequency is somewhat below 5%. Minnesota Whites, consisting largely of Scandinavian stock, shown for comparison in table 1 shows a value of 8.50%. The B gene appears to be completely absent from full-blooded American Indians and Australian aborigines. (See the comprehensive tables of Mourant et al., '58).

Secretors and non-secretors

Saliva specimens from 169 donors o the bloods examined in this study were tested in Korea by Won for the presence of the water-soluble form of the ABO(H antigens. Recognized techniques (Lehrs '30; Morgan, '48; Cazal and Lalaurie, '52 Boyd and Shapleigh, '54; Dunsford an Bowley, '55) were employed. Sastisfactor controls of saliva from known secretor and non-secretors were used. The result of these tests are shown on table 2.

From the table it is seen that the persons tested for the secretor state were nc selected on a basis of the normal distribution of ABO blood groups in Koreans a shown on table 1. Of the 169 person whose saliva was tested, 140 or 82.84% were secretors and 29 or 17.16% were non-secretors. These findings among Korean differ somewhat from the 119 or 24.24% non-secretors found among 491 person tested in Liverpool by Clarke et al. ('56 They differ also from the findings of Ma son and Piper ('47) among the Ute Indians in which all of 79 or 100% wen found to be secretors. Likewise, Chow and Lewis ('55) found 100% secretor among 115 Blood Indians of Alberta, Canada.

Among the 169 persons studied for th secretor property 18 families were investigated for the heredity of the secreting type The results of this study are shown o table 3.

From 18 families with 29 children ther were no exceptions to the expected distribution in accordance with the laws o Mendelian inheritance. The children fro the recessive non-secretor × non-secreto matings were all non-secretors. These fin ings agree as far as we know with all previous investigations of secretion types (Schiff and Sasaki, '32; Morzycki, '33; Matson and Brady, '36; Zieve, Weiner and Fries, '36; Suzuki, '36; Moharram, '43; Race et al., '49; and Andersen, '52) which include 466 families, (1,259 children) of which 32 families were non-secretor × non-secretor matings having 87 children, all of whom were non-secretors. Our findings bring that total up to 484 families (1,288 children) and 34 non-secretor × non-secretor matings having 91 non-secretor children.

Bloods from 80 persons whose saliva was tested for the secretor type were tested in Korea with anti-Le^a serum. The results of these tests are shown on table 4.

In the absence of Le^b antiserum the 80 specimens of blood were tested only with anti-Le^a. From table 4 it is apparent that the secretor type was demonstrable only in saliva specimens from the 64 persons whose blood was not agglutinated with anti-Le^a serum. All the Le(a+) donors were non-secretors. These results agree with the early findings of Grubb ('48) that all persons whose red cells were Le (a+) were also salivary non-secretors of A, B or H substance. The saliva specimens were not tested for the presence of Lewis antigens. In the absence of Lutheran antisera, blood specimens from secretors and non-secretors were not tested for the Lutheran antigens now known to be linked to the secretor types (Mohr, '51; Sanger and Race, '58).

The M-N system

Potent and specific commercial antisera were used in doing the M and N tests. The tests were done by the slide technique and the reactions were satisfactory with control cells of known types. The results of the M and N tests are shown on table 5.

TABLE 2

Frequency of secretors and non-secretors in 169 Koreans

Group	Number tested	Secretors		Non-secretors	
		Number	Per cent	Number	Per cent
O (H)	14	12	85.72	2	14.28
A	66	55	83.34	11	16.66
B	55	45	81.82	10	18.18
AB	34	28	82.35	6	17.65
Total and average %	169	140	82.84	29	17.16

TABLE 3

Families tested for secretion—Seoul, Korea

Matings	Number families	Number of children				Total children
		Secretors		Non-secretors		
		No.	%	No.	%	
Sec. × Sec.	9	13	86.66	2	13.33	15
Sec. × non-sec.	7	6	60.00	4	40.00	10
Non-sec. × non-sec.	2	0	0.00	4	100.00	4
Total	18	19		10		29

TABLE 4

Secretor types and Lewis blood types—Seoul, Korea

Lewis blood type	Number tested	Saliva secretor type	
		Secretor	Non-secretor
Le(a+)	16	0	16
Le(a−)	64	64	0
Total	80	64	16

TABLE 5

The M-N system

Peoples	Number tested	Number and per cent of phenotypes						Per cent gene frequencies		Sum of gene frequencies
		M		MN		N		M	N	M + N
		No.	%	No.	%	No.	%			
Koreans (this study)	394	91	23.097	201	51.015	102	25.888	48.604	51.396	100.00
Koreans (Yamamato, '43)	836		27.9		51.4		20.8	53.6	46.4	100.00
Chinese (Rife) (Wiener, '43)	1029		33.24		48.59		18.17	57.5	42.5	100.00
Japanese (Wiener, '43)	7551		28.99		49.93		21.09	54.0	46.0	100.00
Am. Indians (Chippewa) (Matson, '54)	161		52.8		38.0		9.2	71.8	28.2	100.00
Am. Indians (Navaho) (Boyd, '49)	361		84.5		14.4		1.1	91.7	8.3	100.00
Minn. Whites (Matson, '54)	300		35.00		49.7		15.3	59.9	40.1	100.00

TABLE 6

Rh-Hr system

People	Number tested	Number and per cent of phenotypes[1]															
		CCDEe		CCDee		CcDEE		CcDEe		CcDee		ccDEE		ccDEe		ccDee	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Koreans (this study)	387	4	1.034	153	39.535	1	0.258	140	36.176	31	8.010	47	12.145	10	2.584	1	0.258

[1] None of the following phenotypes were observed: CCDEE, CCddEE, CCddEe, CCddee, Ccddee, CcddEE, CcddEe, CcddEe, Ccddee, ccddEE, ccddEe, ccddee.

It is obvious from this study that the percentage of gene frequencies of the M and N genes are almost equal, the value for N being a little higher than that for M (51.396% and 48.604% respectively). These results differ somewhat from those reported by Yamamato ('43) who found values of 53.6% frequency for the M gene and 46.4% for the N gene. There appears to be a general pattern of the distribution of the M and N factors and their genes in the Orientals listed on table 5. The American Indians on the other hand show a frequency of the M gene to be high, varying from 71.8% in the Chippewa (Matson, Koch and Levine, '54) to 91.7% in the Navaho of New Mexico (Boyd and Boyd, '49). The incidence of the M and N phenotypes and gene frequencies among 300 Whites in Minnesota (Matson, Koch and Levine, '54) is shown for comparison. Tests for S and s in the MN Ss system were not done.

The Rh-Hr system

Five antisera were used, i.e., anti-C, anti-D, anti-E, anti-c and anti-e. These were checked for potency and specificity. A slide test was performed on all the specimens and doubtful or weak reactions were checked by a tube test using antisera from a different lot or from a different manufacturer. A slide control done on each specimen ruled out false positives due to rouleaux, auto-agglutination, contamination or other causes. Anti-D, anti-E anti-c were prepared in our own laboratories, whereas the remaining antisera were obtained from commercial distributors. The anti-C and anti-e gave generally weaker reactions than the other anti-sera. Therefore the results on these were questioned at times and the tests were repeated. The hr″(e) determinations were done only on bloods possessing the rh″(E) factor in order to use sparingly the scarce anti-e serum. The chromosome frequencies were computed by the formulae of Mourant ('54).

The number and per cent of Rh-Hr phenotypes are shown on table 6.

Chong Duk Won ('58) tested a total of 3,602 specimens of blood from Koreans for Rh_o(D) factor and found only 6 or 0.166% to be Rh_o(D) negative. In 1954, J. B. Walsh et al., reported only one Rh_o(D) negative in 1,000 tested and In Dul Kim et al. in 1958, reported on Rh_o(D) negative among 1,500 tested.

The chromosome frequencies of the Rh-Hr factors in Koreans compared with some other populations are shown on table 7.

A study of table 7 shows that Koreans have a high chromosome frequency of CDe(R^1) compared to American and Australian Whites, Basques and Chippewa Indians. The cDE(R^2) chromosome frequency is high compared to that reported for Chinese, Basques and Whites. It is less however, than the frequency of the chromosome in Chippewa and Maya Indians. The cDe(R^o) and CDE(R^z) chromosomes appear to be present but no CdE (R^y), Cde(r′), cdE(r″) or cde(r) chromosomes appear to be present in the 387 specimens of Korean blood studied.

The Kell-Cellano System

All 394 specimens were tested for the Kell antigen using reliable anti-Kell serum prepared in the Minneapolis War Memorial Blood Bank laboratories. The blood specimens were several days old upon arrival from Korea and since it is known that Kell antigen does not travel as well as other blood antigens it is possible that the completely negative results reported here would be somewhat different if fresh blood had been available for testing. The findings are shown on table 8.

All the Korean bloods tested were Kell negative, presumably homozygous Cellano positive. From these tests it appears that the Kell gene is extremely rare among Koreans if indeed it is present at all. These observations are similar to those reported for some tribes of American Indians (Matson and Swanson, '59; Chown and Lewis, '53) but differ appreciably from the incidence of the K gene reported for Caucasians (Matson, Koch and Levine, '54; Ikin et al., '52). Other comparative data are given in tables by Mourant ('54).

The Duffy system

The Duffy factor was determined in this study only with anti-Fy^a sera since these were the only ones available to us. Commercial antisera from two manufacturers were employed and these appeared to react

TABLE 7

Rh-Hr chromosome frequencies in Koreans compared with some other populations

People	Number tested	R^z CDE	R^1 CDe	R^y CdE	r' Cde	R^2 cDE	r'' cdE	R^o cDe	r cde
Koreans (this study)	387	0.0082	0.6197	0.0000	0.0000	0.3148	0.0000	0.0573	0.0000
Am. Indians (Chippewa) (Matson, '54)	161	0.0190	0.3150	0.0000	0.0000	0.5870	0.0790	0.0000	0.0000
Am. Indians (Maya) (Matson, '59)	553	0.0206	0.5219	0.0000	0.0000	0.4061	0.0000	0.0514	0.0000
Southern (Chinese) (Simmons et al., '50b)	250	0.0049	0.7591	0.0000	0.0000	0.1951	0.0000	0.0409	0.0000
Basques (Chalmers, '49)	383	0.0000	0.3756	0.0000	0.0147	0.0707	0.0025	0.0050	0.5315
Australian Whites (Simmons et al., '50a)	300	0.0000	0.4207	0.0000	0.0126	0.1381	0.0126	0.0187	0.3973
American Whites (Wiener, '52)	743	0.0015	0.4165	0.0000	0.0045	0.1369	0.0036	0.0260	0.4109

TABLE 8

Kell system in Koreans—data among other peoples for comparison

Peoples	Number tested	Number and per cent of phenotypes				Gene frequencies		Sum of gene frequencies
		K+		K–				
		No.	%	No.	%	K	k	
Koreans (this study)	394	0	0.00	394	100.00	0.0000	1.0000	1.0000
American Indians (Chown, '53)	280	0	0.00	280	100.00	0.0000	1.0000	1.0000
Maya Indians (Matson, '59)	553	3	0.54	550	99.46	0.0027	0.9973	1.0000
American Whites (Matson, '54)	300	33	11.00	267	89.00	0.0566	0.9434	1.0000
English (Ikin et al., '52)	1166	90	7.72	1076	92.28	0.0394	0.9606	1.0000
Negroes (N.Y.C.) (Miller, '51)	200	7	3.50	193	96.50	0.0177	0.9823	1.0000

TABLE 9

Distribution of the Duffy (*Fy^a*) *factor among Koreans—data for other peoples for comparison*

Peoples	Number tested	Number and per cent of phenotypes				Gene frequencies		Sum of gene frequencies
		Fy(a+)		Fy(a–)				
		No.	%	No.	%	Fy^a	Fy^b	
Koreans (this study)	394	393	99.75	1	0.25	0.9950	0.0050	1.0000
English (Ikin et al., '52)	1166	764	65.52	402	34.48	0.4128	0.5872	1.0000
Asiatic Indians (Cutbush, '50)	55	51	92.73	4	7.27	0.7304	0.2696	1.0000
Chinese (Miller, '51)	103	102	99.03	1	0.97	0.9015	0.0985	1.0000
Ainu-Japanese (Simmons, '53)	51	50	98.04	1	1.96	0.8600	0.1400	1.0000
Chippewa Indians (Matson, '54)	161	158	98.14	3	1.86	0.8636	0.1364	1.0000
Maya Indians (Matson, '59)	553	495	89.51	58	10.49	0.6762	0.3238	1.0000
American Negroes (Miller, '51)	200	52	26.00	148	74.00	0.1398	0.8602	1.0000
Minnesota Whites (Matson, '54)	300	204	68.00	96	32.00	0.4344	0.5656	1.0000

satisfactorily when tested with known positive and negative controls. The results of the tests are shown on table 9.

From the table it appears that the frequency of the Fy^a gene is high among Koreans (99.50%). Compared to the frequencies in the English (Ikin et al., '52) (41.28%), American Whites (Matson et al., '54) (43.44%) and American Negroes (Miller et al., '51) (13.98%), these values are indeed high. So far as we know this unusual high gene frequency of the Fy^a gene in Koreans appears to be the highest reported in any people. Other peoples in whom this high frequency is approached are the Chinese (Miller et al., '51) (90.15%), Chippewa Indians (Matson and Swanson, '59) (86.36%), Ainu-Japanese (Simmons et al., '53) (86.00%), Norwegian and Lapps (Allison et al., '52 (81.89%). A relatively high frequency fo gene Fy^a is reported also among Asiati Indians (Cutbush and Mollison, '50 (73.04%).

The Diego Di^a antigen

Through the generosity of Drs. M. Lay risse, Banco de Sangre, Venezuela and B Chown, Rh Laboratory, Winnipeg, Mani toba, Canada, enough anti-Di^a was mad available to test 277 blood specimens. Th anti-serum was specific and potent wit known controls. The findings are recorde as positive or negative reactors to anti-Di serum and genotypes are calculated o the assumption that there is a correspond ing allele Di^b although this has not bee established definitely. The results of th tests are recorded on table 10.

TABLE 10

The distribution of the Di^a antigen in Koreans and other populations

People	Investigator	Number tested	Per cent of phenotypes		Per cent of gene frequencie	
			Di(a+)	Di(a–)	Di^a	Di^b
Korean	This study	277	6.14	93.86	3.13	96.87
Caribe, Venezuela	Layrisse et al., '55	121	35.54	64.46	19.71	80.29
Guajros, Venezuela	Layrisse et al., '55	152	5.26	94.74	2.67	97.33
Piaroas, Venezuela	Layrisse and Arends, '56	24	12.50	87.50	6.46	93.54
Guahibos, Venezuela	Layrisse and Arends, '56	76	14.47	85.53	7.52	92.48
Caingangs, Brazil	Junqueira et al., '56	48	45.83	54.17	26.40	73.60
Carajas, Brazil	Junqueira et al., '56	36	36.11	63.89	20.07	79.93
Chippewa Indians	Lewis et al., '56	148	10.81	89.19		
Maya Indians	Matson and Swanson, '59	363	17.63	82.37	9.24	90.76
Non-Maya Indians, Mexico	Matson and Swanson, '59	244	15.16	84.84	7.89	92.11
Chinese	Layrisse and Arends, '56	100	5.00	95.00		
Japanese	Layrisse and Arends, '56	65	12.31	87.69	6.39	93.61
Japanese	Lewis et al., '56	77	7.79	92.21		
Polynesians	Simmons, '57	80	0.00	100.00		
Australian Aborigines	Simmons, '57	162	0.00	100.00		
Papuans	Simmons, '57	23	0.00	100.00		
New Britain Natives	Simmons, '57	74	0.00	100.00		
Eskimos	Lewis et al., '56	156	0.00	100.00		
Caucasians	Levine et al., '56	1000	0.00	100.00		

The table shows that the percentage incidence of the phenotype Di(a+) for the 277 Koreans tested is 6.14% and the per cent of frequency for the Di^a gene is 3.13%. It is noteworthy that Koreans, Amerinds (Matson and Swanson, '59; Layrisse et al., '55; Layrisse and Arends, '56; Junqueira et al., '56; Lewis et al., '56), Chinese (Layrisse and Arends, '56), and Japanese (Lewis et al., '56; Layrisse and Arends, '56) all possess the Di^a antigen whereas Polynesians (Simmons, '57), Australian Aborigines (Simmons, '57), New Britain Natives (Simmons, '57), Eskimos (Lewis et al., '56b) and Caucasians (Levine et al., '56) do not have it.

SUMMARY

1. A study of the distribution of the hereditary blood factors among 394 Koreans has been reported.

2. The blood specimens were tested for he following antigens: A, B, O, M, N, C, D, E, c, e, Duffy, Kell, Lewis(Le^a) and Diego. The number tested and percentage ncidence of phenotypes and the calculated per cent of gene frequencies are presented n appropriate tables.

3. In common with other Asian peoples, he Koreans have a high frequency of the B gene. The frequencies of the M and N genes appear to be almost the same. As n other Orientals the Rh factor is almost universally present, with the cde(r) chromosome being entirely absent. There is a high chromosome frequency of CDe(R^1). The cDE(R^2) chromosome frequency is high compared to that reported for Chinese, Basques and Whites. All Korean bloods tested were Kell negative. The frequency of the Fy^a gene is high (99.50%). The percentage frequency of the Di^a gene is 3.13%.

4. The secretor status for the ABH antigens was determined on 169 saliva specimens and the heredity of this character was studied in 18 families including 29 hildren. About 82.84% of the Koreans tested were shown to be secretors. Family tudies showed no exceptions to the expected distribution of secretors and non-secretors in accordance with the laws of Mendelian inheritance.

LITERATURE CITED

Allison, A. C., O. Hartmann, O. J. Brendemoen and A. E. Mourant 1952 The blood groups of the Norwegian Lapps. Acta Path. Microbiol. Scand., *31:* 334–338.

Andersen, A. 1952 Investigations in the inheritance of the characters secretor and non-secretor. Ibid., *31:* 448–461.

Boyd, W. C., and L. G. Boyd 1949 The blood groups and types of Ramah Navaho. Am. J. Phys. Anthrop., N.S. *7:* 569–574.

Boyd, W. C., and E. Shapleigh 1954 Separation of individuals of any blood group into secretors by use of a plant agglutinin (lectin). Blood, *9:* 1195–1198.

Cazal, P., and M. Lalaurie 1952 Recherches sur quelques phyto-agglutinins specifiques des groupes sanguins ABO. Acta Haemat., *8:* 73–80.

Chalmers, J. N. M., E. W. Ikin and A. E. Mourant 1949 The ABO, MN and Rh blood groups of the Basque people. Am. J. Phys. Anthrop., N.S. *7:* 529–544.

Chown, B., and M. Lewis 1953 The ABO, MNSs, P, Rh, Lutheran, Kell, Lewis, Duffy and Kidd blood groups and secretor status of the Blackfeet Indians of Alberta, Canada. Ibid., N.S. *11:* 369–383.

——— 1955 The inheritance of the blood group and secretor genes in the Blood Indians of Alberta, Canada. Ibid., *13:* 473–478.

Clarke, C. A., J. W. Edwards, D. P. W. Haddock, A. W. Howel-Evans, R. B. McConnell and P. M. Sheppard 1956 ABO blood groups and secretor character in duodenal ulcer, Population and sibship studies. Brit. Med. J., *2:* 725–731.

Cutbush, M., and P. L. Mollison 1950 The "Duffy" blood group system. Heredity, *4:* 383–389.

Dunsford, I., and C. C. Bowley 1955 Techniques in Blood Grouping, 1st edition. Charles C Thomas, p. 157.

Furuhata, T. 1933 Value of blood grouping in Anthropology. Kanazawa Medical College, *June,* 1–22.

Grubb, R. 1948 Correlation between Lewis blood group and secretor character in man. Nature, *162:* 933.

Ikin, E. W., A. C. Kopec, A. E. Mourant, D. M. Parkin and J. A. E. Walby 1952 Cited by Mourant, A. E., table 35, p. 405.

Junqueria, P. C., P. J. Wishart, F. Ottensooser, R. Pasqualin, P. L. Fernandes and H. Kalmus 1956 The Diego blood factor in Brazilian Indians. Nautre, *177:* 41.

Kim, I. D. 1958 Unpublished communication.

Kirihara, S. 1924 Über die Isohamagglutination beim menschlischen Blute. Ztschr. f. Klin. Med., *99:* 522.

Layrisse, M., T. Arends and R. Dominguez-Sisco 1955 Nuevo grupo sanguineo encontrado en descendientes de indios. Acta Med. Venez., *3:* 132–138.

Layrisse, M., and T. Arends 1956 High incidence blood group found in Venezuelan Indians. Science, *123:* 633.

——— 1956 Investigacion del factor Diego en Japoneses y Chinos. Acta Cientifica Venez., *7:* 11–12.

Lehrs, H. 1930 Über gruppenspezifische Eigenschaften des menschlichen speichels. Ztschr. f. Immunitatsf., *66:* 175–192.

Levine, P., E. A. Robinson, M. Layrisse, T. Arends and R. Dominguez-Sisco 1956 The Diego blood factor. Nature, *177:* 40–41.

Lewis, M., H. Ayukawa, B. Chown and P. Levine 1956 The blood group antigen Diego in North American Indians and in Japanese. Nature, *177:* 1084.

Lewis, M., B. Chown and H. Kaito 1956b Further observations on the blood factor Di^a. Ibid., *178:* 1125.

Matson, G. A., and E. O. Brady 1936 A procedure for the determination of isoantigens in saliva. J. Immunol., *30:* 445–457.

Matson, G. A., E. A. Koch and P. Levine 1954 A study of the hereditary blood factors among Chippewa Indians in Minnesota. Am. J. Phys. Anthrop., N.S. *12:* 413–426.

Matson, G. A., and C. L. Piper 1947 Distribution of the Blood Groups, M-N, Rh types and secretors among the Ute Indians of Utah. Ibid., N.S. *5:* 357–368.

Matson, G. A., and J. Swanson 1959 Distribution of hereditary blood antigens among the Maya and non-Maya Indians in Mexico and Guatemala. Ibid., N.S. *17:* 49–74.

Miller, E. B., R. E. Rosenfield and P. Vogel 1951 On the incidence of some of the new blood agglutinogens in Chinese and Negroes. Am. J. Phys. Anthrop., *9:* 115–126.

Moharram, I. 1943 The group properties in the saliva of the Egyptian population. Lab. and Med. Progress, *4:* 1–13.

Mohr, J. 1951 Estimation of linkage between the Lutheran and the Lewis blood groups, Acta Path. Microbiol. Scand., *29:* 339–344.

Morgan, W. T. J., and W. M. Watkins 1948 The detection of a product of the blood group O gene and the relationship of the so-called O substance to the agglutinogens A and B. Brit. J. Exp. Path., *29:* 159–173.

Morzycki, G. 1933 L'heredite des proprietes de la secretion des facteurs constituants des groupes O, A, B, dans la salive. C. R. Soc. Biol., *115:* 658.

Mourant, A. E. 1954 The Distribution of the Human Blood Groups. Blackwell Scientific Publications, Oxford, p. 1–438.

Mourant, A. E., A. C. Kopec and K. Domaniewska 1958 The ABO Blood Groups—Comprehensive Tables and Maps of World Distribution, 1s edition. Charles C Thomas, table I, pp. 20–15

Race, R. R., R. Sanger, S. D. Lawler and D. Bertin shaw 1949 The Lewis blood groups of 7 families. Brit. J. Exp. Path., *30:* 73–83.

Sanger, R., and R. R. Race 1958 The Luthera Secretor linkage in man: support of Mohr findings. Heredity, *12:* 513–520.

Sarkisian, S. S. 1956 Major blood groups i Koreans. U. S. Armed Forces Med. J., 7 1320–1322.

Schiff, F., and H. Sasaki 1932 Der Aussche dungstypus, ein auf serologischen Wege Nach weisbares Mendelndes Merkmal. Klin. Woch *11:* 1426–1429.

Simmons, R. T. 1957 The Diego(Di^a) bloo group: tests in some Pacific peoples. Natur *179:* 970–971.

Simmons, R. T., and J. J. Graydon 1950a O servations on recent discoveries connected wit the blood groups Rh (C^w and D^u) MN(S Lewis(Le), together with the Rh and M- types and agglutinogen P in White Australian Med. J. Anat., *1:* 681–688.

Simmons, R. T., J. J. Graydon, N. M. Semple an R. Green 1950b The A_1-A_2-B-O, M-N and R blood groups in southern Chinese: Hak-Ka Cantonese and Hokkas. Ibid., *11:* 917–922.

Simmons, R. T., J. J. Graydon, N. M. Semple an S. Kodama 1953 A collaborative genetic survey in Ainu: Hidaka Island of Hokkaid Am. J. Phys. Anthrop., N.S. *11:* 47–82.

Suzuki 1936 (Juzenki-Zasski) (Japanese) A ter Race, R. R., and R. Sanger, Blood Grou in Man, 3rd edition, 1958. Blackwell Scienti Publications, Ltd., Oxford, pp. 1–377.

Walsh, R. J., O. Kooptzoff, D. Dunn and K. S. S 1954 Personal communication to Won.

Wiener, A. S. 1943 Blood Groups and Tran fusion, 3rd edition. Table, p. 320.

Wiener, A. S., E. B. Gordon and L. Cohen 19 A new rare Rhesus agglutinogen. Am. J. Hu Genet., *4:* 363–372.

Won, C. D. 1958 Personal communication.

Yamamato 1943 From table by Wiener, Bloo Groups and Transfusion, 3rd edition. Charl C Thomas, p. 326.

Zieve, I., A. S. Wiener and J. H. Fries 1936 O the linkage relations of the genes for allerg disease and the genes determining blood group M N types and eye colour in man. Ann. Euge *7:* 163–178.

Blood Group Frequencies in New Guinea

I. THE SENTANI PAPUANS

J. L. DE VRIES [1] AND L. E. NIJENHUIS [2]
Public Health Service, Hollandia, Dutch New Guinea[3] and Central Laboratory of the Netherlands Red Cross Blood Transfusion Service, Amsterdam, Holland[4]

The Sentanis live on the shores and the islands of Lake Sentani, just south west of Hollandia.

An extensive ethnological study about the Sentanis was published in 1928 by P. Wirtz who considered the Sentanis to be a mixed population that by being isolated for a long time have developed into a homogeneous group with its own somatic properties, language and culture.

The Sentani language is completely different from that of the surrounding populations. Within the Sentani language there are however several dialects. On the whole the various populations understand each other except for several linguistic elements that are not related.

According to Wirtz the oldest population is situated in the central part of the Sentani region. The central Sentanis divide themselves into two groups of different origin. Some settlements are believed to have been populated from heaven, the others from the interior of the earth. However such a division into two classes is found all over New Guinea, just as it is on the Moluccas and other islands as far as the island Lombok. Thus this information from the population is not necessarily an indication that they are composed of two components.

The western and eastern parts of the Sentani district have, according to Wirtz, a younger population than the central part. Wirtz presumes that the Sentanis originate from the border of Australian and Dutch New Guinea. In connection herewith it is interesting to mention that prominent Sentanis from the central region recognized their wood carving patterns in those of the Jafi district, while patterns from other parts of New Guinea (Wissel Lakes, Asmat) appeared unknown to them. This district (Jafi) situated 70 miles south-south east of Lake Sentani is inhabited by several tribes. They live in the region between the Sepik and the Idenburg River on both sides of the 141° eastern length. It has also been known that patterns from the Lake Sentani region correspond with those of the upper course of the Sepik.

Blood samples for this investigation have been collected in the following ways:

1. One series came from the village Ifar Besar in the central Sentani district.
2. Another series collected in three different villages, consist mostly of blood samples from the same central region. However one of these villages (Ifar Babronko) has been influenced by the western Sentani region. The other two villages Babronko and Simporo belong to the Central region.
3. One series came from the western part (Dojo).
4. Two series from three villages Sekori, Sawiron and Sabron that are situated at a certain distance from Lake Sentani, the first two, south of the lake, Sabron north west of the lake. Although initially we received information from the natives that these villages also belonged to the Sentani tribe, it appeared later on that the population contained only a negligible Sentani component. The main component of this population consists of elements from populations that live in the area west and south of Lake Sentani.

---

[1] Government Medical Officer, Dutch New Guinea.

[2] Biologist, Central Laboratory of the Netherlands Red Cross Blood Transfusion Service, Amsterdam, Holland.

[3] Director: Dr. J. Bierdrager.

[4] Director: Dr. J. J. van Loghem, Jr.

MATERIAL AND METHODS

The greater part of the blood samples was collected by means of a finger prick. A small quantity of blood was added to tubes that contained a citrate glucose solution (Rous-Turner), while as an antiseptic "Cialit" was added in a dilution of 1/20,000. One shipment contained samples of 1 ml clotted blood. The tubes were sent in a thermosflask with ice, by air to Amsterdam, where blood grouping was performed. The study was done from November, 1956 to July, 1957. Because of complicated family relations it was difficult to avoid taking blood from related persons but thanks to the assistance of a Sentani Papuan civil servant, it has been possible to select half of the samples.

For blood grouping the following antisera were used: anti-A, -B, -A+B, -M, -N, anti-P, anti-C, -c, -D, -E. For most blood samples also anti-He and anti-Fy^a and with some series anti-K, anti-A$_1$ (only blood groups A and AB), anti-C^w, anti-Di^a, anti-Tj^a (= anti-P+P$_1$) (only for P-negatives) as well. Moreover all E-positives were tested with anti-e, while special attention was paid to the presence of D^u and E^u. The results of the different series were compared by means of the χ^2 test.

RESULTS AND DISCUSSION

When comparing the results of the 5 series it appeared that the blood group distribution of the villages Sekori, Sawiron and Sabron differ considerably from the remaining series. No significant difference could be shown between the central district and the western part of the Sentani district.

The ABO blood groups

In the ABO frequencies (table 1) we notice especially the low B frequency in the Sentanis and the high A and the low O frequency in Sekori. In Papuans A frequencies vary from 7.5% at the Wissel Lakes (Simmons, Graydon, Semple and Swindler, '56) to 29.7% in the Bainings from New Britain (Simmons et al., '56 and Semple, Simmons, Graydon, Randmae and Jamieson, '56) and 29.3% in the Papuans from the south west coast of New Guinea (Bylmer, '35). In New Guinea the B-frequency varies from 9.9% (Bylmer, '35) to 19.6% (Daru and Kikori, Simmons, Graydon, Woods, Smith and Lancaster, '46), while 25.2% was observed in the Bainings from New Britain (Simmons et al., '56; Semple et al., '56). As far as blood group frequencies in Papuans are known now, the Sentanis correspond best with the Gorokas from the central highlands of Australian New Guinea, while the Sekoris have similarities with the south west coast (Bylmer, '35).

	O	A	B
Goroka (Semple et al., '56)	72.9	16.8	10.2%
Mimika district (Bylmer, '35)	61.3	29.3	9.9%

Blood grouping of 107 samples of group A and 14 of group AB with anti-A$_1$ serum gave exclusively positive reactions.

TABLE 1

	Observed		Expected		Gene frequences	
	Number	%	Number	%		
			Sentani			
O	125	52.08	125.8	52.5		
A	75	31.25	74.2	30.9	O	72.4%
B	33	13.75	32.0	13.4	A	18.9%
AB	7	2.92	7.9	3.3	B	8.7%
Totals	240	100.00	239.9	100.1		100.0%
			Sekori a.o.			
O	47	36.42	46.3	35.9	O	59.9%
A	57	44.19	57.7	44.7	A	29.9%
B	16	12.40	17.2	13.4	B	10.2%
AB	9	6.98	7.9	6.1		
Totals	129	100.00	129.1	100.1		100.0%

The MNS blood groups

Although the M frequencies (table 2) are not very low, such as in Daru and Kikori (Simmons et al., '46) and in Chimbu (Simmons et al., '56 and Semple et al., '56) with M gene frequencies of resp. 3.9 and 2.1%, they are not higher than is known in some other Papuan populations (Simmons et al., '56; Semple et al., '56). The S-frequencies (table 3) are however lower than in other Papuans. In Sekori c.s. no S was found at all. This indicates a very low frequency in this group. Also in the Sentanis the frequency is low, only 2.2% S genes were found. So far, low S frequencies were found in the Gorokas (6.3%) and at the Wissel Lakes 0.8%, in a few groups on New Britain (0% and 1.1%) and on the Schouten Islands (3.9%) (Nijenhuis and van der Hoeven, '56). Higher S frequencies (more than 10%) were found a.o. in the series of Sanger and co-workers and Walsh and co-workers (13.4%) and in the Chimbu (15.2%) (Simmons et al., '56).

On a total of 324 tests not a single He positive was found (table 6). Also in view of earlier observations it seems probable that the He factor occurs seldom or not at all in New Guinea (Nijenhuis and van der Hoeven, '56).

The P blood groups

The P frequencies show a considerable difference between Sentani and Sekori (table 4). Similar differences in P-frequencies have also been observed elsewhere: on Biak only 42.76% P-positives

TABLE 2

	Observed		Expected		Gene frequences	
	Number	%	Number	%		
Sentani						
M	5	2.08	2.9	1.22		
MN	43	17.92	47.1	19.64	M	11.04%
N	192	80.00	190.0	79.14	N	88.96%
Totals	240	100.00	240.0	100.00		100.00%
Sekori a.o.						
M	0	0.00	1.2	0.94	M	9.7 %
MN	25	19.38	22.6	17.52	N	90.3 %
N	104	80.62	105.1	81.54		
Totals	129	100.00	128.9	100.00		100.00%

TABLE 3

	Observed		Expected		Gene frequences	
	Number	%	Number	%		
Sentani						
MMS+	0	0.0	0.0	0.0		
MMS−	3	2.2	1.6	1.2	MS	0.0%
MNS+	0	0.0	0.6	0.5	Ms	10.7%
MNS−	23	16.9	25.4	18.6	NS	2.2%
NNS+	6	4.4	5.2	3.8	Ns	87.1%
NNS−	104	76.5	103.1	75.9		
Totals	136	100.0	135.9	100.0		100.0%
Sekori a.o.						
MMS+	0	0.0	0.0	0.0		
MMS−	0	0.0	0.9	1.3		
MNS+	0	0.0	0.0	0.0	MS	0.0%
MNS−	15	23.1	13.2	20.4	Ms	11.5%
NNS+	0	0.0	0.0	0.0	NS	0.0%
NNS−	50	76.9	50.9	78.4	Ns	88.5%
Totals	65	100.0	65.0	100.1		100.0%

were found (Nijenhuis and van der Hoeven, '56); in the central highlands of Australian New Guinea 57.2% ; at the Wissel Lakes 63% (Simmons et al., '56; Semple et al., '56) while on New Britain 89.5% and 35% P-positives were observed. Obviously there exists in these populations considerable differences in P-frequencies.

A small number of P-negative (P_1-negative) blood samples that were tested with anti-Tj^a (anti-P_1+P) appeared to react 100% positive with this serum (table 6).

The Rhesus blood groups

The Rh frequencies are according to Papuan measures divergent (see Simmons et al., '56). In the Sentanis the cDE and cDe frequencies are high, the CDe frequency is low. They correspond to a great extent with the frequencies of the Gorokas (Semple et al., '56); CDe 80.1%, cDE 12.9%, cDe 7.1%.

Semple and co-workers ('56) also found high cDE frequencies in the Papuans from the Wissel Lakes (12.1%) and in the Bainings from New Britain (16.8%), but both groups have lower cDe frequencies 2.9% and 1.4%. In Sekori c.s. Rhesus frequencies are just the other way round: the cDe chromosome was not observed while CDe has a very high frequency. Most similarity exists with the inhabitants of the island of Biak (Nijenhuis and van der Hoeven, '56) CDe 92.9%, cDE 5.7%, cDe 1.1%, CDE 0.3%. On the south coast of Australian New Guinea, Simmons and co-workers ('46) also found a high CDe frequency 94.5%, however the cDE frequency is lower (2.0%) and the cDe frequency higher, also 2.0%, while Simmons and co-workers found 1.5% CDE.

Summarizing it appears that the blood group distribution of the Sentani Papuans shows similarities with the Gorokas in all blood group systems. When blood group frequencies have been investigated in more Papuan tribes along the coast we might find that they have similarities with the Sekori c.s. Much blood grouping will have to be done in New Guinea before the entire pattern of blood group distribution will be clear to us. With Rh typing special attention was given to the presence of the variant factors D^u and E^u. Simmons and co-workers ('56) mention to have found D^u on New Britain but not on New Guinea.

TABLE 4

	Sentani		Sekori a.o.			Gene frequences	
	Number	%	Number	%		Sentani	Sekori a.o.
P+	117	49.0	84	65.6	P	28.5%	41.4%
P−	122	51.0	44	34.4	p	71.5%	58.6%
Totals	239	100.0	128	100.0		100.0%	100.0%

TABLE 5

	Observed		Expected		Gene frequences	
	Number	%	Number	%		
			Sentani			
CCDee	155	64.58	155.2	64.64		
CcDEe	48	20.00	46.7	19.46	CDe	80.4%
CcDee	28	11.66	28.9	12.06	cDE	12.1%
ccDEE	3	1.25	3.5	1.46	cDe	7.5
ccDEe	4	1.67	4.4	1.81		
ccDee	2	0.83	1.3	0.56		
Totals	240	99.99	204.0	99.99		100.0%
			Sekori a.o.			
CCDee	119	92.2	118.2	91.6		
CcDEe	9	7.0	10.6	8.2	CDe	95.7%
ccDEE	1	0.8	0.2	0.2	cDE	4.3%
Totals	129	100.0	129.0	100.0		100.0%

TABLE 6

	Sentani		Sskori a.o.	
Tj(a+)	24	100%[1]		
Tj(a−)	0	0%		
Total	24			
K+	0	0%		
K−	165	100%		
Total	165			
Fy(a+)	166	100%	49	100%
Fy(a−)	0	0%	0	0%
Total	166		49	
Di(a+)	0	0%		
Di(a−)	84	100%		
Total	84			
He+	0	0%	0	0%
He−	240	100%	84	100%
Total	240		84	

[1] Determinations with anti-Tj^a were performed only with P-negative blood samples.

Also Walsh found a D^u antigen on New Britain. When blood grouping the Sentani and Sekori Papuans with anti-D a considerable number of weak agglutinations was observed. In some cases the reaction was completely or almost negative.

In these extreme cases tests were done with several anti-D sera, with the saline method as well as with the albumin method. In this way 12 blood samples were classified as D^u, all belonging to the Rh type CCD^uee. Identification of these D^u antigens very much depends on the kind of anti-D serum used. Because with the Rh typing different anti-D sera were used in various series, one series gave more D^u than another. In the third series not a single D^u was found. In later series it appeared that with anti-D serum, used in the third series, all D^u antigens gave positive reactions. The invesitgation for E^u will be published elsewhere more extensively (Nijenhuis, de Vries, Soeparto Sedjodihardjo, Jonxis and de Graaf, '58). We should just like to mention that in the Sentanis 2 E antigens and in Sekori c.s. 5 E antigens could be classified with certainty as E^u. Eighty-three blood samples (Sentanis) gave only negative reactions with anti-C^w serum.

Other blood groups

Blood grouping was also done with anti-sera, anti-K, anti-Fy^a and anti-Di^a. With anti-K and anti-Di^a only negative reactions were observed, with anti-Fy^a all blood samples tested reacted positively. Kell positives seem extremely rare in Papuans. Semple and co-workers ('56) found one in 52 tests in the central highlands, Nijenhuis and van der Hoeven ('56) observed one in 183 blood samples in Papuans from Biak. The Duffy factor was always found positive in Papuans except by Semple and co-workers ('56) who found three negatives in 30 samples in Papuans from the Wissel Lakes. Lack of Di^a positives agrees with the results of Simmons ('57); no Di^a could be shown in Polynesians, Australians and Papuans. Nijenhuis and Soeparto Sedjodikardjo did not find Di^a positives in Javanese from Semarang.

SUMMARY

Blood grouping has been done in Papuans from the Sentani Lake district. No difference could be observed between the inhabitants of the central part of the district and the western part.

However, comparatively large differences were shown between the Sentani Papuans and the inhabitants of a region just south and west of Lake Sentani. The blood group frequencies found are given in tables 1 to 6. The frequencies of the Sentanis correspond very much with the results of Semple and co-workers in Goroka Papuans.

ACKNOWLEDGMENTS

Our thanks are due to Dr. O. Kranendonk, Public Health Service, New Guinea, who assisted in collecting the blood samples, to Dr. R. T. Simmons, Melbourne, Australia, for his critical remarks, and to Dr. Ph. Levine, Raritan, USA, and Dr. A. E. Mourant, London, who provided us with samples of anti-Di^a and anti-S.

LITERATURE CITED

Bijlmer, H. J. T. 1935 Bloedgroep en ras. Ned. Tijdschr. v. Geneesk., *79:* 2738–2755.

Nijenhuis, L. E., and J. A. van der Hoeven 1956 Blood group frequencies in Papuans from Biak (Isles of Schouten). Vox Sanguinis, n.s. *1:* 241–249.

Nijenhuis, L. E., J. L. de Vries, R. Soeparto Sedjodihardjo, J. H. R. Jonxis and W. de Graaf The occurrence of E-variants (E^u) in some nonwhite populations. To be published.

Nijenhuis, L. E., and R. Soeparto Sedjodihardjo Blood group frequencies in Indonesians from Semarang (Java). To be published.

Semple, N. M., R. T. Simmons, J. J. Graydon, G. Randmae and D. Jamieson 1956 Blood group frequencies in natives of the Central Highlands of New Guinea and in the Bainings of New Britain. Med. J. Austr., *2:* 365–371.

Simmons, R. T., J. J. Graydon, E. F. Woods, W. A. H. Smith and H. O. Lancaster 1946 Further observations on the Rh and Hr factors and the blood group frequencies in Papuans. Ibid., *1:* 537–539.

Simmons, R. T., J. J. Graydon, N. M. Semple and D. R. Swindler 1956 A blood group genetical survey in West Nakanai, New Britain. Am. J. Phys. Anthrop., n.s. *14:* 275–286.

Simmons, R. T. 1957 The Diego (Di^a) blood group: test in some Pacific peoples. Nature, *179:* 970.

Wirtz, P. 1928 Beitrag zur Ethnologie der Sentanier (Holländisch Neuguinea). Nova Guinea, *14:* 251–369.

Blood Group Antigens Among the Paraujano

M. LAYRISSE, Z. LAYRISSE AND J. WILBERT
Centro de Investigaciones del Banco Municipal de Sangre and Fundación "La Salle," Caracas, Venzuela

During the months of November, 1958 and January, 1959, the authors had the opportunity of visiting the Paraujano Indians of Venezuela.[1] At present the habitat of this tribe is located in the general area of the lagoon of Sinamaica (fig. 1) (11° long., 71°50′ lat.), while in former times they also inhabited stretches of the sea coast, the western shore of Lake Maracaibo, and the river banks south of Sinamaica. They were reported in that area as early as 1499, and most probably have been living there since prehistoric times.

In 1499 the explorer Alonso de Ojeda discovered the pile-dwellings of these Indians along the shores of the so-called "Saco de Maracaibo," and in 1520 the Paraujano were visited by Ambrosius Ehinger who encountered them on the western shore of Lake Maracaibo. He mentioned them by the name of *Onotos* which, like other denominations, e.g., *Alcojolados, Aliles, Toas, Zaparas* and *Sinamaicas*, are synonymous for Paraujano (Jahn, '27).

Although there remain several smaller Paraujano villages in the general area of Sinamaica, the nucleus of the tribe survives in 4 settlements around the lagoon itself, and these most likely represent the same villages Ehinger already mentioned in 1531 (Oviedo y Valdés, 1851). According to the 1958 census carried out by the División de Malariología of Maracaibo, there exist today around the lagoon some 260 houses, sheltering a total population of 1,348 individuals.

Culture identification

According to the early sources and judging from our own experience, Paraujano culture may best be described as Marginal, featuring a simple technology, a food collecting economy, an unstratified social structure, and a little developed religious system. The culture of the Paraujano would seem to have something in common with a large number of hunting and fishing peoples who in prehistoric times spread all across Venezuela from the Andes to the Orinoco Delta. Although this chain of distribution has been interrupted under the impact of Arawakean, Caribbean, and European immigrations, remnants of these early populations remain traceable, while some of them have even managed to survive with their autochtonous culture still in function.

The Paraujano construct stilt-dwellings and for communication and transportation they largely rely on dugouts. Pottery and weaving does not seem ever to have been practiced by them, but basketry for the production of a variety of containers and of sleeping mats constitutes an important industry of theirs.

Paraujano economy is based on fishing and collecting of wild fruits. Hunting is of minor importance, but since the first coconut-trees were planted, some 100 years ago, the selling of the nuts and their byproducts gave a new orientation to the economy of these lake dwellers.

The social structure of modern Paraujano features: bilateral descent, Hawaiian cousin terminology, bilocal and restricted neolocal residence, bilateral endo-demes, bilateral extension of incest taboos, restricted polygyny, independent nuclear families, and lineal terms for aunts and nieces.

Religion seems to have been orientated towards Shamanism exclusively, functioning mainly in life crisis situations, e.g., birth, initiation, sickness, and death (Wilbert, '59).

---

[1] The ethnic group under discussion must not be confused with the Paraujano Indians of Guiana.

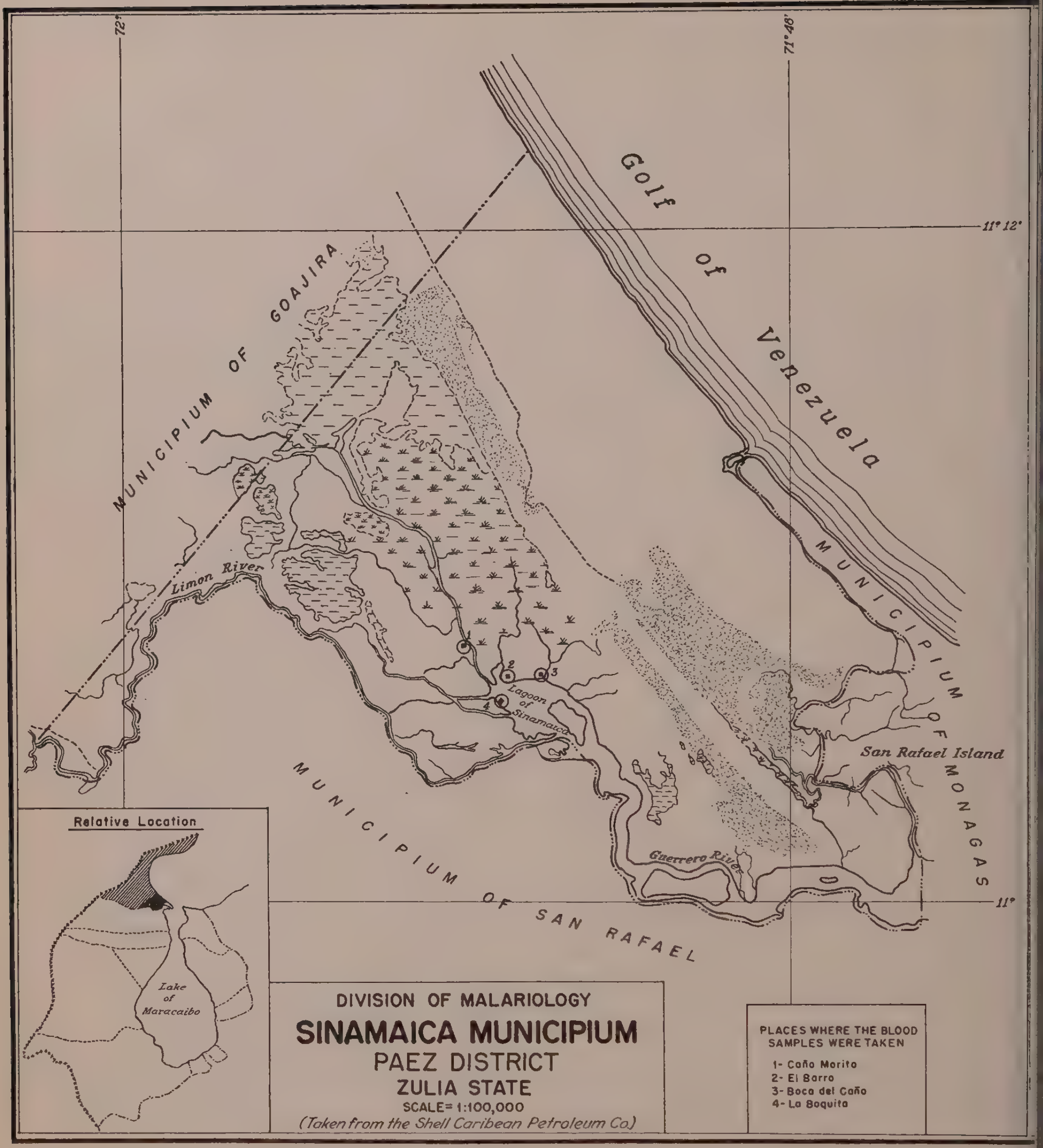


Figure 1

Blood group antigen studies

Material. The material of research comprises 120 blood samples collected from unrelated Paraujano Indians of the Sinamaica group. The blood samples were tested for the 9 well established blood systems as well as for the Diego system. The incidence of Js^a, which probably will become the 11th blood group system, ha also been determined. Electrophoresi studies of the hemoglobin were performe by using a pH 8.6 barbital buffer.

For the studies of the blood group systems the blood samples were tested wit the following antibodies:

1. Anti-A, anti-A_1, and anti-B fo A_1A_2BO.

2. Anti-M, anti-N, anti-S, anti-s, and anti-U for MNSs.
3. Anti-P_1 (previously called anti-P), and anti-P+P_1 (previously called anti-Tj^a) (Sanger, '55).
4. Anti-C, anti-c, anti-D, anti-E, anti-e and anti-V for Rh.
5. Anti-Lu^a for Lutheran.
6. Anti-K, and anti-k for Kell.
7. Anti-Le^a for Lewis.
8. Anti-Jk^a for Kidd.
9. Anti-Di^a for Diego.
10. Anti-Js^a for Js.

RESULTS

A_1A_2BO. As it will be commented on later, the modern Paraujano tribe is made up mainly by the descendants of the Paraujano Indians with a certain proportion of admixture with Caucasoids and Negroids. The positive frequency of the genes A_1(3.94%), A_2(2.25%), and B (2.25%) give evidence of the interbreeding suspected.

MNSs. As in most of the American Indian tribes, the gene M predominates over the gene N. However, it was not found (60%) to be as high as in other American Indians. The frequency of the gene S (46.64%) is one of the highest frequencies ever found anywhere. Only the Kaingang have shown an S gene frequency higher than that of the Paraujano (Fernández, Junqueira, Kalmus, Ottensooser, Pasqualin and Wishart, '57).

P. Until now no more than 10 tribes have been tested for the P system. Its gene frequency has shown a wide range of from 34% in Diegueños of California (Pantin and Kallsen, '53) and of from 23% in Brazilian Indians (Pantin and Junqueira, '52), to about 85% observed in Blackfoot Indians (Chown and Lewis, '53). As can be seen in table 1, the gene frequency of P_1(29.29%) is very similar to the incidence which was established for the only South American Indian group tested so far.

Rh. The chromosome Ro(cDe), absent in all pure Venezuelan Indian tribes, showed an incidence of 15% which is indicative of Negro admixture. This evidence is reinforced by the finding of 5 individuals carrying the antigen V. The chromosomes CDe and cDE were on the range that is found in other Indian tribes. Not a single Rho negative blood sample was found, although this had also been expected because of the physical evidence of the Negro and White admixture. This result will be commented upon.

Kell. Contradictory results have been obtained in testing this antigen among Indians. Matson, Koch and Levine ('54) reported a frequency of 10.17% among Chippewa Indians but Chown and Lewis ('52) did not find a single positive case in pure-blood Canadian Indians and they also retested the Chippewa Indians (Chown and Lewis, '57) studied by the former authors finding only 5 positive out of the 40 originally said to be K(+).

In South America, Patin and Junqueira ('52) found 10.17% K(+) in Brazilian Indians. While more recently Fernández, Junqueira, Kalmus, Ottensooser, Pasqualin and Wishart ('57) did not observe any positive cases among Kaingangs, Junqueira, Kalmus and Wishart detected 7 positive out of 35 samples from Caraja Indians. The present authors, as yet, have not observed a single case of K(+) in 500 pure Venezuelan Indians tested.

Lutheran. In South America, only the Brazilian Indians have been tested for the Lu^a antigen, finding 16.44% Lu(a+) (Patin and Junqueira, '52). From our material, this antigen has proved to be absent in 500 pure Indians from various tribes of Venezuela (unpublished data).

Lewis. The little data on American Indians available for this system indicate a much lower frequency of the Le(a+) antigen in American Indians than in European and African populations. For the Blackfoot and Blood Indians it has even been shown to be negative (Chown and Lewis, '53). About the results obtained in Goajiro (an Arawak tribe), it is possible that the 5 positive cases found, are due to White-Negro admixture.

Duffy. Like in most American Indians, the frequency of the gene Fy^a in Paraujano (63.49%) is higher than in Caucasoids and Negroids.

Kidd. Since the incidence of the antigen Jk^a has not been studied in South American Indians at all and in only 4 North American Indian tribes, we can only state that the Paraujano showed an in-

TABLE 1

Frequency of blood group antigens in Paraujano Indians

	Modern Paraujano				Prehistoric possible	Paraujano frequency
	Phenotypes (%)			Genes or chromosomes	Phenotypes	Genes
	Number observed	Frequency observed	Frequency expected			
				%	%	%
			A_1A_2BO system			
A_1	9	7.50	7.65	3.94	0	0
A_2	5	4.16	4.21	2.26	0	0
B	5	4.16	4.21	2.26	0	0
A_1B	1	0.83	0.18		0	
A_2B	0	0.00	0.10		0	
O	100	83.33	83.64	91.54	100	100
Total	120	99.98	99.99	99.98	100	100
			MNSs system—All samples U(+)			
MMSS	11	9.16	11.22	MS-33.50	16.45	MS-40.55
MMss	6	5.00	7.25	Ms-26.93	5.05	Ms-22.48
MMMSs	29	24.17	18.04		18.25	
MNSS	5	4.16	8.84		11.68	
MNss	11	9.16	14.22		10.14	
MNSs	37	30.85	24.77		24.78	
NNSS	2	1.66	1.74	NS-13.18	2.07	NS-14.39
NNss	9	7.50	6.96	Ns-26.39	5.09	Ns-22.57
NNSs	10	8.33	6.96		6.48	
Total	120	99.99	100.00	100.00	99.99	99.99
			P system			
P_1	60	50		29.29	32.85	18.06
P_2	60	50		70.71	67.15	81.94
p	0	0		0		
Total	120	100		100.00		
			Rh system			
CCDDEE	0	0.00	0.01	CDE-0.61	0.01	CDE-0.82
CCDEe	1	0.83	0.80		1.24	
CCDee	49	40.85	41.94	CDe-64.76	57.60	CDe-75.90
CcDEE	1	0.83	0.24		0.38	
CcDEe	26	21.67	25.74		35.35	
CcDEeV	2	1.66				
CcDee	21	17.51	19.28		0.00	
CcDeeV	1	0.83		cDE-19.74		cDE-23.28
ccDEE	5	4.16	3.90		5.42	
ccDDEe	9	7.50	5.87	cDe cde } 14.89	0.00	cDe cde } 0.00
ccDEeV	2	1.66				
ccDee	3	2.50	2.22		0.00	
Total	120	100.00	100.00	100.00	100.00	100.00
			Lutheran system			
Lu(a+)	1	0.83	—	Lu^a-0.42	0.00	0.00
Lu(a–)	119	99.16		Lu^b-99.58	100.00	100.00
Total	120	99.99	—	100.00	100.00	100.00
			Kell system			
K	0	0.00	0.17	0.42	0.00	0.00
Kk	1	0.83	0.83	—	0.00	—
kk	119	99.16	99.00	99.58	100.00	100.00
Total	120	99.99	100.00	100.00	100.00	100.00
			Lewis system			
Le(a+)	5	4.16	—	—	0.00	—
Le(a–)	115	95.83	—	—	100.00	—
Total	120	99.99	—	—	100.00	—
			Duffy system			
Fy(a+)	104	86.66	—	Fy^a 63.49	94.49	76.56
Fy(a–)	16	13.33	—	$Fy + Fy^b$ 36.51	5.51	23.44
Total	120	99.99	—	100.00	100.00	100.00
			Kidd system			
Jk(a+)	102	85.00	—	Jk^a 61.28	84.82	61.06
Jk(a–)	18	15.00	—	Jk^b 38.72	15.18	38.94
Total	120	100.00	—	100.00	100.00	100.00
			Diego system			
Di(a+)	12	10.00	—	Di^a 5.14	12.84	6.90
Di(a–)	108	90.00	—	Di 94.86	87.16	93.10
Total	120	100.00	—	100.00	100.00	100.00
			Js system			
Js(a+)	3	2.50	—	1.23	0.00	0.00
Js(a–)	117	97.50	—	98.77	100.00	100.00
Total	120	100.00	—	100.00	100.00	100.00

rmediate incidence between the one ound in White and in Negro populations espectively.

Diego. The gene Di^a showed a frequency f 5.14% which is close to the incidence reviously found in Goajiro Indians (Lay- sse, Arends and Domínguez Sisco, '55). his finding we shall discuss later on in ore detail.

Js. The new blood group antigen Js^a, iscovered by Giblett in 1958, appears to be Negro gene. In recent studies, Layrisse nd Layrisse ('59) found a negative inci- ence of this gene in two Indian tribes. s presence in Paraujano at a rate of hree out of 120 samples should be inter- reted as due to interbreeding with Ne- roes.

Abnormal hemoglobin. Only one ab- ormal hemoglobin of the AS type was ound.

Rate of admixture

According to the tribal history as well as their physical features, modern Parau- ano may be considered as being the re- ult of the interbreeding of three base pop- lations: *Indian, Negroid* (represented y the descendents of West African Ne- roes), and *Caucasoid* (predominantly epresented by the descendents of Span- rds).

Negro admixture. The blood group anti- ens tested and the electrophoretic studies f hemoglobin in the Paraujano, showed hree genes (V, Js^a, hemoglobin S) and ne chromosome (Ro), which could be tilized in estimating the Negro gene flow nto the Paraujano pool. The gene V of he Rh system has been found in a high ncidence in West African Negroes (De Natale, Jack, Race and Sanger, '55), hile in less than 0.5% in Caucasoids, nd even negative in Venezuelan Indians Layrisse, unpublished data).

As mentioned before, the Js^a appears to e a Negro antigen. Since modern North merican Negroes represent the result of nterbreeding of approximately 80% of Vest African Negroes and 20% of Euro- ean Caucasoid (Roberts, '55) and since he incidence of the gene Js^a in North merican Negroes amounts to 10% only, could be estimated that West African Negroes carry this gene in a proportion of 2.5%. This figure will be taken into account for the calculation of Negro admixture in Paraujano.

The hemoglobin S is a useful gene marker in Negroes. Genetic calculations are faced with certain difficulties, since the majority of the homozygous individuals for this hemoglobin die in childhood; in addition, the incidence of this hemoglobin in the population of West African Negroes exhibits a wide range (Livingstone, '58). Still, the presence of one case of a hemoglobin of the type AS among the Paraujano may indicate a Negro admixture of about 7% to 15%.

The chromosome Ro (cDe), likewise is a useful tool for determining the Negro gene flow into a non-Negro population. Nevertheless, for reasons that will be discussed below, the rate of admixture established by employing this chromosome will not be adopted as being representative of the Negro admixture in our Indian population.

The rate of Negro genes which were introduced into the Paraujano population was calculated according to the Glass and Li formula ('53). This formula is expressed as follows:

$$(1 - m)^k = \frac{q_x - Q}{q_o - Q}$$

where k is the number of generations of intermixture, m the percentage of genes in the Paraujano population which were introduced per generation from the descendents of West African Negroes, q_x the V, Js^a or Ro frequency in Paraujano, q_o the gene frequency in prehistoric Paraujano plus frequency of Spaniards, and Q the gene frequencies in West African Negroes.

It could be estimated that an appreciable intermixture of White and Negro with the Paraujano began at the beginning of the 17th century. With regard to the length of generation in the Paraujano tribe, it was not possible to obtain accurate data; however, according to the custom of the Indians to marry rather soon after the girls have passed their first menstruation, it could be said that the length of generation in that tribe is around 20 years. In table 2 is shown the *m* values per generation according to the incidence of V, Js^a and Ro and the amount of Negro genes accumulated after 360 years (18 generations).

TABLE 2

Rate of West African Negro admixture found in the Paraujano Indians; according to Glass and Li's formula

Genes or chromosomes	q_o	Q	q_x	m	Percentage of admixture accumulated during 360 years (18 generations)
V	0	22.54	2.54	0.0064	11.27
Js^a	0	12.50	1.23	0.0057	9.84
Ro(cDe)	5.26	55.00	14.89	0.0120	19.36

Caucasoid admixture. From the results of blood group antigens obtained in the present study it is impossible to estimate the White admixture directly, e.g., by taking into consideration the gene frequencies. This only seems to be possible after subtraction of the Negro genes.

Knowing that practically all South American Indians belong to the group O, and that the Negro admixture in Paraujano amounts to some 10.55%, it appears to be genetically correct to first subtract from the frequency of ABO the genes responsible for the Negro admixture, and then calculate the rate of White admixture. The available ABO data for the West African Negroes (Mourant, Kopec and Domaniewska, '58), show a frequency of 14.97% for the gene A, 12.70% for the gene B, and 72.57% for the gene O; so that 10.55% of these frequencies come up to 1.58% of A, and 1.34% of B.

Since the Paraujano showed an incidence of 6.19% and 2.25% of the genes A and B respectively, there remain 4.61% of A and 0.91% of B after the genes responsible for the Negro admixture have been subtracted. The 51 data on ABO for Spaniards (Mourant, Kopec and Domaniewska, '58) displayed a frequency of 28.24% of the gene A and 6.24% of the gene B. Calculating the percentage of Spanish admixture from the remaining frequency of A and B in Paraujano, 16.32% were obtained when calculating according to the gene A and 14.55% according to the gene B. These figures give an average of 15.45% of Spanish admixture.

Considering the distribution of the various chromosomes of the Rh system, it will be noticed that one or two samples of the phenotype ccddee are missing in spite of the introduction of 26% of White-Neg genes. With respect to the chromosom Ro, it is not unreasonable to suggest th the three samples of phenotype ccDee r sponsible for the frequency of this chron osome are due to Negro admixture.

Since the number of individuals teste was not a very large one and because the absence of phenotype ccddee hinde the appropriate correction for all t phenotypes carrying ccee, there exists certain possibility that one of the phen type ccDee could be due to Spanish a mixture.

In conclusion it may be said that th modern Paraujano represents the result an admixture of: 74% Indian, 15.45 Spanish, and 10.55% West African Negr Whether the proportion of Indian blood made up by Paraujano blood only whether also neighboring tribes contri uted towards it, will be discussed later o The probable blood group antigen distr bution of prehistoric Paraujano is show in table 1. It was calculated by subtrac ing in each blood group system the gen or chromosomes responsible for Whit Negro admixture, and by elevating the r mainder from 74% to 100%.

DISCUSSION

In a previous chapter we have classifie Paraujano culture as being Marginal type. As such it resembles to a large d gree that of the Warrau Indians of t Orinoco Delta. In fact, resemblances certain culture traits, e.g., fishing econom and technology, are so suggestive th ethnologists at times may have felt pr voked to assume a common cultural a possible genetic origin of the two tribe However, while the probability of cultur relationships between the Paraujano a e Warrau may still be open to discus- on, (Kirchhoff, '48), any closer genetic nk between the two tribes appears to be efinitely out of the question. In par- cular we refer to the incidence of the i^{a} and MN antigens. The two Warrau ommunities (Guayo and Winikina) tested y Layrisse, Arends and Wilbert, ('58), howed a Di^{a} frequency of 3.69% among e Guayo-Warrau and 0% among the Vinikina-Warrau, while the M gene fre- uencies were 50.61% and 36.79% re- pectively. The few Diego-positive cases ncountered among the Guayo-Warrau ere interpreted as being the result of in- erbreeding with neighboring tribes, such s the Arawak and Carib with whom the eripheral Warrau have been in some con- act for many centuries.

Two other Venezuelan tribes were tested y us whose culture appears to be basic- lly of the Marginal type, e.g., the Piaroa nd the Guahibo (Layrisse and Arends, 57; Wilbert, '58a). There are a number f differences between the cultures of the Varrau and that of the Piaroa and Guah- bo, which until now have not precisely een worked out by cultural anthropolo- ists. However, judging from the frequen- ies of the Diego antigen in "Marginal eoples" of Venezuela, genetic differences egan to appear.

Although then culturally related to the Marginal tribes of Venezuela, genetically peaking we regard the Paraujano as be- onging to a different ethnic stock. This ifference is also beared out by linguistics, ccording to which the Paraujano belong o the Arawakean family, whereas Mar- inal tribes of Venezuela apparently form ndependent linguistic stocks. Consider- ng the characteristics of Paraujano cul- ure it is surprising, to a certain extent, to earn of their Arawak affiliation since, as rule, Arawak culture features elements f a higher degree of development.

It should be remembered, however, that ingustic similarity does not imply cul- ural homogenity; and there is no reason why the Arawak characteristic of the Par- ujano should be doubted because of cul- ural divergence between them and the majority of Arawak tribes. Referring to the Goajiro, the Arawak speaking neighbors f the Paraujano, we probably deal with a parallel case of a lower leveled Arawak culture. This, however, will be difficult to prove, since by the early adoption of cattle, Goajiro culture has so completely been modified that little trace of their original culture remains.

Drawing on the results of glottochronology (Swadesh, '58), we are led to assume that the transcontinental expansion of the Arawak across extensive parts of northern South America commenced some 6,500 years ago. Since agriculture seems to have been practiced by South American tribes only considerably later, the expansion necessarily started as that of hunting and fishing peoples. The ancestors of the Paraujano, and in our opinion also those of the Goajiro, would seem to have formed a part of their own rather than of the more recent agricultural Arawak, who continued to expand only during the last 2,000 years.

According to a lexico-statistic calculation carried out by Swadesh, the Paraujano and Goajiro languages separated some 20 minimum centuries ago (personal communication). Before that time the two different tribes of today most probably formed a closely related ethnic group, and in order to find out whether this presumption could be substantiated by genetics, the authors recently carried out a blood group study among the Goajiro. Without going into details, it may be stated that as a result of this study, both tribes were found to be genetically identical in most of the blood antigens tested, including the Diego group (Layrisse, Layrisse and Wilbert, '59).

It may be of some interest to point out that soon after the Paraujano and Goajiro separated, some 2,000 years ago, intermixture of their blood stocks has not taken place at any considerable rate. We can mention two main factors which have been responsible for this isolation: (a) the different social structures of the tribes, and (b) the strong *esprit de corps* of both groups together with a deep rooted tribal prejudice.

We have previously circumscribed the social structure of the Paraujano. The Goajiro are socially organized in matrisibs. Descent is matrilineal, residence predominantly matrilocal with exceptional avunco-locality, kinship terminology is of the Crow type. The marriage rule is only partially exogamous and marriage requires the accumulation of a considerable bride price. The individual identifies himself most strongly and throughout his life with his sib of origin (Wilbert, '58b).

Apart from the obstacles arising from the different economic patterns of the Paraujano (fishermen) and the Goajiro (cattle herders), the different patterns of their social structure make intermarriage between partners of the two tribes almost impossible. There is only a slight probability of a lower-class Goajiro marrying a Paraujano, since the expected bride price would not be altogether out of reach for a Paraujano, and since more recent neolocality among the latter groups would facilitate such a contract.

As a second isolating factor we must consider the deep-rooted prejudice of the Goajiro towards their Paraujano neighbors, and which should not be underestimated. Even today, the Paraujano are looked down upon by the Goajiro as "animals feeding on stinking fish," and we do not hesitate to consider this circumstance as a very important factor which impeded a more extensive intertribal gene flow.

These arguments, then, lead us to the conclusion that our Paraujano blood samples are representative of a genuine Arawak population with a relatively retarded type of culture.

For the sake of future Diego research we would finally like to raise the hypothetical question, whether for reasons of two emerging types of Arawak cultures, we should expect two different racial origins of the Arawaks, or whether the different cultural types rather represent two phases of a cultural development achieved by genetically one and the same ethnic element. Our Goajiro blood samples do not lend themselves towards answering this question, since the cultural identification of that tribe is uncertain. It would be interesting, therefore, to test a typical Tropical Forest Arawak tribe. For the time being we prefer to classify our Paraujano blood samples as typical of a Marginal Arawak population. Insisting on these details may seem to be overemphasizing the issue a little, but there are reasons to assume that the varying frequencies of the Di^a antigen in different Indian populations migh eventually turn out to be due to raci differences, which in turn can only be i terpreted if the populations in questio have carefully been identified by all ava able means.

SUMMARY

The Paraujano Indians of Venezuela li in the general area of the lagoon of Si amaica, Zulia State (11° long., 71°5 lat.). Although there are several small Paraujano villages in the general area Sinamaica, the nucleus of the tribe su vives in 4 settlements around the lago itself.

The Paraujano culture may best be d scribed as Marginal, featuring a simp technology, a food collecting economy, unstratified social structure and a little d veloped religious system. Linguisticall they belong to the Arawak family.

The studies of blood group antigens 120 blood samples from unrelated Para jano Indians of the Sinamaica Gro showed the following percentage of ge or chromosome incidence:

ABO system: A$_1$–3.94, A$_2$–2.26, B–2. and O–91.54.

MNSs system: MS–33.50, Ms–26. NS–13.18 and Ns–26.39.

P system: P$_1$–29.29 and P$_2$–70.71.

Rh system: CDE–0.61, CDe–64.7 cDE–19.74 and cDe+cde 14.89.

Lutheran system: Lu^a–0.42 and Lu 99.58.

Kell system: K–0.42 and k–99.58.

Lewis system: Le(a+) 4.16 (phen type).

Duffy system: Fy^a–63.49 and Fy+Fy 36.51.

Kidd system: Jk^a–61.28 and Jk^b–38.

Diego system: Di^a–5.14 and Di–94.

Js system: Js^a–1.23 and Js–98.77.

The results of the incidence of A and of the ABO system, V of the Rh syste and Js^a antigen showed that the mode Paraujano Indians is the result of int mixture of approximately 74% Indians presented by the descendants of the p historic Paraujano, 10.55% of Negr represented by West African Negroes, a 15.45% of the descendants of Spaniar

ACKNOWLEDGMENT

This work was supported in part by grant from the Fundación Creole, Carac

We wish to thank Miss Iris Dugarte, Adelina Ojeda, Norma Matute and Anna Jancew, for their technical assistance. We are also indebted to Drs. Guzman García Martin, Bartolome Zunimo (Zona XV Malariología, Maracaibo) and Dr. Alonzo Núñez Montiel, Miss Rosa Matilde Hernández and Carmen Juárez (Banco de Sangre de Maracaibo) for their collaboration in the collection of blood samples.

We are greatly indebted to Dr. Eloise Giblett (King County Central Blood Bank, Seattle, Washington), A. E. Mourant (The Lister Institute, London), Kurt Stern (Blood Center, Mount Sinai Medical Research Foundation, Chicago), R. T. Simmons (Commonwealth Serum Laboratories, Victoria, Australia), Philip Levine (Ortho Research Foundation, Raritan, New Jersey), J. P. O'Riordan (The National Blood Transfusion Association, Dublin). M. Shapiro (The South African Blood Transfusion Service, Johannesburg), and T. J. Greenwalt (Junior League Blood Center, Milwaukee) for supplying us with critical anti-sera.

LITERATURE CITED

Chown, B., and M. Lewis 1953 The ABO, MNSs, P, Rh, Lutheran, Kell, Lewis, Duffy and Kidd blood groups and the secretor status of the Blackfoot Indians of Alberta, Canada. Am. J. Phys. Anthrop., *11:* 369–383.

De Natale, A., A. Cahan, J. A. Jack, R. R. Race and R. Sanger 1955 V: a "new" Rh antigen, common in Negroes, rare in White people. J. Am. Med. Assoc., *159:* 247–250.

Fernández, J. L., P. C. Junqueira, H. Kalmus, F. Ottensooser, R. Pasqualin and P. Wishart 1957 P.T.C. thresholds, colour vision and blood factors of Brazilian Indians Kaingangs. Am. J. Human Genet., *22:* 15–21.

Giblett, E. R. 1958 Js a "new" blood group antigen found in Negroes. Nature, *181:* 1221–1222.

Glass, B., and B. B. Li 1953 The dynamics of racial intermixture an analysis based on the American Negro. Am. J. Human Genet., *5:* 1–20.

Jahn, A. 1927 Los Aborígenes del Occidente de Venezuela. Caracas, pp. 32–34.

Junqueira, P. C., H. Kalmus and P. Wishart 1957 P.T.C. thresholds, Colour vision and blood factors of Brazilian Indians, Carajas. Am. J. Human Genet., *22:* 25.

Kirchhoff, P. 1948 Food-gathering tribes of the Venezuelan llanos. Handbook of South American Indians, *4:* 445–468.

Layrisse, M., T. Arends and R. Domínguez Sisco 1955 Nuevo grupo sanguineo encontrado en descendientes de Indios. Acta Med. Venez., *3:* 132–138.

Layrisse, M., and T. Arends 1957 The Diego system. Steps in the investigation of a new blood group system. Further studies. Blood, *12:* 115–122.

Layrisse, M., T. Arends and J. Wilbert 1958 Peculiar distribution of the Diego factor among the Warrau. Nature, *181:* 118–119.

Layrisse, M., and Z. Layrisse 1959 The frequency of the new blood group antigen Js^a among Southamerican Indians. Nature, *184:* 640.

Layrisse, M., Z. Layrisse and J. Wilbert 1960 Blood group antigens in Goajiro Indians. In press.

Livingstone, F. B. 1958 Anthropological implications of sickle cell gene distribution in West Africa. Am. Anthropologist, *60:* 533–563.

Mourant, A. E. 1954 The Distribution of the Human Blood Groups. Blackwell Scientific Publications, Oxford.

Mourant, A. E., A. C. Kopec and K. Domaniewska-Sobezak 1958 The ABO Blood Groups. Blackwell Scientific Publications, Oxford.

Oviedo y Valdés, G. F. 1851 Historia General y Natural de las Indias, islas y tierra firme del Mar Océano. Madrid, *2:* 278–300.

Pantin, A. M., and P. C. Junqueira 1952 Blood groups of Brazilian Indians. Am. J. Phys. Anthrop., *10:* 395–406.

Pantin, A. M., and R. Kallsen 1953 Blood groups of the Diegueño Indians. Ibid., *11:* 91–96.

Roberts, D. R. 1955 The dynamics of racial intermixture in the American Negro. Some anthropological considerations. Am. J. Human Genet., *7:* 361–367.

Sanger, R. 1955 An association between the P and Tj^a system of blood groups. Nature, *176:* 1163–1164.

Swadesh, M. 1958 La linguistica de las regiones entre las civilizaciones mesoamericanas y andinas. 33 Congreso Internacional de Americanistas, San José de Costa Rica, 1958, In press.

Wilbert, J. 1958a Datos antropológicos de los Indios Piaroa. Memorias de la Sociedad de Ciencias Naturales, La Salle, *18:* 155–183.

——— 1958b Kinship and social organization of the Yecuána and Goajiro. Southeastern J. of Anthrop., *14:* 51–60.

Ripples on a Gene-pool: The Shifting Frequencies of Blood-type Alleles Among the Indians of the Hupa Reservation

FREDERICK S. HULSE
Department of Anthropology, University of Arizona, Tucson, Arizona

In the northwestern part of California, in aboriginal days, lived several tribes of distinct linguistic stocks. They were in rather close proximity to one another, geographically, and in culture they shared in common a number of characteristics reminiscent of the Northwest Coast. This area could, in fact, be considered as a cultural borderland, having received influences both from California and from tribes located much further to the north. Not only did these people place their dependence upon salmon fishing, but much emphasis was placed upon wealth as a source of prestige, and much care was lavished upon the finish and embellishment of artifacts (Kroeber, '25). Like the Northwest Coast itself, the country is heavily forested by a variety of conifers, for the rainfall is ample; and it is very mountainous, with deep valleys separated by steep high ridges.

The Indians who populated this country belonged mainly, although not entirely, to the Hupa, the Karok and the Yurok tribes. The Hupa, of Athapaskan stock, occupied the lower valley of the Trinity River; the Yurok, who speak a language doubtfully classified Algonkian lived along the Klamath River between its mouth and its juncture with the Trinity; while the Karok, a Penutian tribe, dwelt in the valley of the Klamath above that point. The Wintun, a tribe who speak a Hokan tongue, occupied the upper part of the Trinity valley and much of the Sacramento valley in the interior.

Representatives of all of these groups are now to be found on the Hupa Reservation, an area of some 200 square miles, which centers at the confluence of the Klamath and the Trinity. By far the greatest number of native inhabitants claim to be of Hupa origin, but, during the present century if not before, Indians from as far away as Minnesota and Oklahoma have come to live there and have intermarried with the local people, so that many of the younger Indians have derived genes from three or even 4 widely scattered tribes.

Indeed, the Karok and the Wintun, who contribute little to the existing gene pool, are the only tribes distinctively Californian insofar as linguistic affiliations are concerned. How and when—or why—the Yurok appeared on the scene appears to be unknown: their closest linguistic relations are the Blackfoot. The Hupa themselves cannot have reached this area much more than a 1000 years ago, at least according to the evidence of glottochronology (Hoijer, '56; Hymes, '57). A few other languages of Athapaskan affiliation are also spoken in the adjacent regions of California and Oregon, but these appear to have diverged from Hupa some 8 or 9 hundred years ago, while the time of divergence between the Pacific Coast and Northern branches of the stocks is variously estimated at 1,000 to 1,400 years. It must have taken a certain amount of time for the ancestors of the Hupa to wander from Canada to California, but there is no way to estimate just how much, nor is evidence yet available from which we might infer the route which they took.

The research upon which this paper is based was financed by funds derived from the license fees of bars and taverns in the State of Washington, which must, under Initiative 171, be devoted to biological and medical research. The collection of blood samples was made under the field supervision of Mr. Arthur Oswald, a graduate student at the University of Washington, and with the cooperation of local medical and educational authorities and of the residents of the reservation, most especially the Tribal Council. Blood samples were air-mailed to the University, and were tested there, either at the physical anthropology laboratory by Mr. Melville Firestone, a graduate student, or by technicians at the King County Central Blood Bank, who were kind enough to offer their services when, as often happened, so many samples arrived at once that the labor of several persons was required to accomplish the work with the necessary dispatch. To all of the persons and institutions named above, the author is most grateful.

Tests were conducted to determine the A_1A_2BO, the CcDE, the MN, and the Duffy antigens of the samples received. The sera used were from the Ortho Pharmaceutical Laboratories and Wadleigh Laboratory. Slide tests were run to determine anti-A_1, anti-A_2, anti-B, anti-c, anti-M, and anti-N reactions; while anti-C, anti-D, anti-E and anti-Fy^a reactions were determined by the test-tube method. The indirect Coombs test was of course used in dealing with the Duffy factor. A small amount of anti-e serum, contributed by the Ortho Laboratories, was used on as many as possible of the blood samples, and proved of great assistance in checking for accuracy and for the internal consistency of the sample.

Not all of the blood samples could be tested for each factor: our supply of anti-Fy^a, for instance, was exhausted on two separate occasions, and about 100 bloods had hemolyzed before replenishments arrived. Consequently, the size of the different series differs to some extent. In all, 373 persons were kind enough to permit samples of their blood to be drawn. This operation was performed by piercing the earlobe with a disposable lancet, and collecting 5 capillary tubes full of blood. The tubes were at once stopped with plasticene, and kept under refrigeration for as much as was possible of the time until the testing procedure could be undertaken. A few of the individuals who donated blood were not Indians at all, but married to Indians and living on the reservation. They are not included in the study of gene-frequencies in the population, but are considered in the analysis of the kindreds to which they belong.

Non-Indians have been living in this neighborhood, of course, for well over a century. Early fur-traders, including Russians, visited the environs, at least, of the Hupa-Yurok-Karok country; and during the period of the gold rush even the more remote mountain valleys were prospected by a great variety of adventurers from many parts of the world. Certainly some left their bones in the vicinity, and there can be little doubt that some left their genes. Africans and Orientals as well as men of European origin were among the gold seekers. Rather later, and in many cases to remain permanently, came loggers and settlers to farm the lowlands. This group of outsiders was composed almost entirely of individuals of European descent: Yankees, Swiss and more recently Portuguese and some Mexicans of possibly mixed ancestry. As a result, the Indians now resident on the Hupa Reservation include a large majority of individuals who are partly Caucasian. Younger Hupa, both men and women, frequently have gone as far as San Francisco to work for some years or permanently. Those who return are quite likely to bring home with them spouses, or a child or two of uncertain parentage. Many of the children now in school were born in hospitals at Eureka or Arcata, cities not far from the reservation. Genetically, then, the Hupa of today are by no means the same as were the Hupa of a few generations ago. It is one of the purposes of this paper to examine the extent and variety of genetic change among them, insofar as these changes are reflected in shifting frequencies of the blood-type alleles.

The sample which was drawn from the Indian residents of the Hupa reservation consists of all those individuals who were available and willing during the late fall and early winter of 1957, either in their homes, at health clinics, or at schools. It was not drawn by a random process, and is not representative on the basis of age, for more than two-thirds of the persons typed were school children. Many families on the reservation are large, but the mean size of sibships is not believed to be large enough to have led to this effect. Whenever possible, the parents, older sibs and other relatives of school children already typed were sought out, so that as many complete kindreds as possible might be typed. It is recognized that in a population of infinite, or even of very great size, this procedure could be expected to skew the picture of gene-frequency distribution. In this specific case, however, we are dealing with a really small group, less than a thousand in number. Large sibships are more likely to contribute, in proportion to their size, than are small sibships, to the gene-pool of the coming generation. Any skewing which results from typing as many members as possible from each kindred, should be in the direction of foreshadowing the future rather than reflecting the past. Comparisons between the generations, which are made, indicate the existing gene-frequencies of each.

In age, 243 members of the sample are less than 16 years old, 78 from 16 through 45, and 35 are 46 or older. Since there are 177 males and 179 females in the sample, the sex ratio suggests random distribution by sex, nor does the sex ratio vary with age, except in the most minor and insignificant manner.

Attempts were of course made to obtain the greatest possible amount of information concerning tribal and racial origin. As is well known, however, precise data in this field is not to be anticipated. I cannot guarantee the accuracy of the classification by percentage of ancestry which has been used in this paper, but believe it to be a close approximation of genetic fact. The attitudes of the Hupa towards premarital and extra-marital intercourse is such that illegitimacy appears to be readily acknowledged. Not one instance occurred in which the parentage recorded would have been genetically impossible, in all of the kindreds which were studied. The total series is then, to the best of our knowledge, composed of 282 Hupa, 27 Yurok, 19 Karok and 28 Indians of other tribal affiliations, including Sioux, Choctaw, Wintun, Shoshone, Cherokee, Chippewa and "Okalahoma (?)." Any who are part Hupa are listed in the Hupa group above: some of them are part Yurok, part Karok or part Sioux. Of the entire group, however, only 31 are, so far as could be ascertained, purely Indian in ancestry, of whom 17 are alleged to be pure Hupa.

RESULTS

Table 1 presents the phenotype frequencies in all the blood type series as tested, for the entire sample not broken down by age, sex, tribal origin or degree of Indian ancestry, while table 2 presents the gene-frequencies, in percentages, calculated therefrom. It will be noted that the alleles B and A_2 are both present, as might be expected in a group which is partly

TABLE 1

Phenotpic frequencies of the ABO, MN, RH and Duffy series of the Indians on the Hupa Reservation

A_1	A_2	B	AB	O	M	MN	N	Fy(a+)	Fy(a–)
75	7	26	3	242	132	145	61	210	40

CDE	CcDE	cDE	CcDe	CDe	cDe	cde	CcDEe	cDEe
28	76	57	74	75	3	8	8	8

TABLE 2

Gene frequencies of the ABO, MN, RH and Duffy series of the Indians on the Hupa Reservation

A_1	A_2	B	O	M	N	Fy^a	Fy^b
0.12	0.01	0.04	0.83	0.61	0.39	0.60	0.40

CDE	cDE	CDe	cDe	cde
0.06	0.29	0.47	0.03	0.15

European in ancestry. The gene-frequency of B is, however, 4 times greater than that of A_2, which is not the case in Western Europe. The phenotype frequency of A_1B is precisely what one would expect as a result of random mating, given the existing frequencies of A_1 and of B. This appearance of genetic equilibrium, however, is not completely maintained in the examination of MN frequencies. There is a deficieny of the heterozygote phenotype MN which deviates from expectation to a degree which might be expected in only one quarter of such samples. This is by no means statistically significant, but, in a population known to have been constantly receiving genes from outside, it is suggestive.

The presence of Rh negative phenotypes is also to be anticipated in a population with partly European ancestry, and the frequency calculated for this allele would lead to the estimate that about one third of the genetic makeup of the Indians on this reservation today is derived from across the Atlantic, since there is no evidence that r is aboriginal in any tribe. The presence of the gene R^0 might, perhaps, be taken as an indication of an African contribution to the local gene-pool, but this is less certain. Genetic equilibrium appears to be missed to approximately the same degree as in the MN series; for the most part due to a deficiency in the heterozygote phenotype CcDE. The positive allele, or Fy^a, in the Duffy series, is more frequent than the negative, as in most, but apparently not all, of the American Indian tribes so far tested. The percentage of negative reactions is, however, rather high, which may or may not be attributable to the admixture of genes from overseas so clearly demonstrated in the ABO and RH series of blood-types.

Fortunately, the sample is large enough so that it can easily be sub-divided in various ways for further analysis. In order to find out the direction and degree of change in gene-frequencies which is bound to take place when any genetic isolate receives contributions from other gene pools, such subdivisions have been made using age, alleged degree of Indian ancestry, and tribal affiliation as the criteria. Comparisons between the subgroups which form the present population may lead to inferences concerning aboriginal gene-frequencies, as well as to extent, if any, to which a truly random assortment of genes is being delayed by culturally determined mating preferences.

Analysis

By age

Tables III, IV, V and VI contrast the phenotypic and gene-frequencies, in the various blood-type series, of the young as contrasted to the older individuals. Those who are 15 years old or younger are considered to represent the coming generation, which has not yet started to reproduce. Those who are 16 or older are treated as the present reproducing generation, since the youngest mother in the sample had given birth to her first baby at that age.

The contrast between the generations in the ABO locus is striking. Despite the fact that both old and young contain all the possible phenotypes, the inferred gene-frequency for A_2 is three times as great, and that for A_1 has increased by six-sevenths in the younger as contrasted to the adult generation. The probability of such a difference being due to chance alone has been calculated by Chi-square, and it is found that such a result might be expected in less than 1% of cases: there is no question of its statistical significance. What it signifies we can readily discover by examining the geneologies, which indicate the derivation of the increase in A_1 and A_2 from such places as India, New Mexico and Ireland, among others. That mixture with outsiders had already produced a genetic effect upon the older generation, however, is demonstrated by the fact that one individual of type AB is 48 years old.

There would seem to have been little if any shift in gene-frequencies between the generations in the MN series. The rise from 36 to 41% in the allele N is not significant when tested by Chi-square. The deficiency of heterozygotes mentioned earlier is concentrated in the younger generation; and among these children the difference from expectation reaches the 0.04 probability level, which may be regarded as significant, and which is certainly puzzling. Inasmuch as most American Indians series

TABLE 3

Blood-group frequencies at the ABO locus, for older and younger generations of Indians on the Hupa Reservation

	Phenotype distribution					Gene-frequencies			
	A_1	A_2	B	A_1B	O	A_1	A_2	B	O
Younger generation	61	5	19	—	150	0.13	0.03	0.04	0.80
Older generation	14	2	7	3	92	0.07	0.01	0.04	0.88

TABLE 4

Blood-type frequencies at the MN locus, for older and younger generations of Indians on the Hupa Reservation

	Phenotype distribution			Gene-frequencies	
	M	MN	N	M	N
Younger generation	89	95	47	0.59	0.41
Older generation	43	50	14	0.64	0.36

TABLE 5

Blood-type frequencies at the RH locus, for older and younger generations of Indians on the Hupa Reservation

Phenotype distribution

	CDE	CcDE	cDE	CcDe	CDe	cDe	cde	CcDEe	cDEe
Younger generation	23	57	36	41	62	3	5	1	1
Older generation	5	19	21	33	13	—	3	7	7

Gene frequencies

	CDE	cDE	CDe	cDe	cde
Younger generation	0.06	0.23	0.52	0.04	0.15

TABLE 6

Blood-type frequencies at the Duffy locus, for older and younger generations of Indians on the Hupa Reservation

	Phenotype distribution		Gene-frequencies	
	Fy(a+)	Fy(a−)	Fy^a	Fy^b
Younger generation	149	29	0.59	0.41
Older generation	61	11	0.61	0.39

have a much greater frequency of M than do Europeans, a greater difference between the generations might also have been expected.

Phenotypic frequencies in the RH series among the older generation differ considerably from those of the younger generation. One reason for this is that very few samples of children's blood were tested with anti-e serum, which was not available until most of the laboratory work had been done. Taking due account of this fact, however, the increase in frequency of CDe with time is notable. The difference between the older and younger groups, as tested by Chi-square, is significant to about the 0.001 probability level, and thus calls for closer examination so that it may be explained. The phenotypes CDE and cde show no shift in frequency, but cDE is apparently being replaced by CDe, and the heterozygous phenotype CcDe revealed by testing with anti-c serum is far more common in the older than the younger generation. As in the MN series, the younger generation reveals a deficiency of demonstrable heterozygotes, but the deviation from genetic equilibrium is only to an extent which might be expected in one-third of all such cases, and is therefore not statistically significant. In contrast, the older generation is clearly not a breeding population in the proper sense: gene frequencies can only be approximated, not accurately calculated. No such approximations have a degree of probability as great as one in a thousand. This can however, be readily explained by the fact that the older generation includes most of the non-California Indians in the sample. Within such a diverse group, there is no reason to expect genetic equilibrium to exist. The speed with which a balance is being approached by the next generation is an interesting demonstration of the Hardy-Weinberg law coming into operation.

In the Duffy series there appears to be no shift in frequencies from one generation to the next, and therefore no indication from this analysis that the rather high percentage of the negative gene is due to the extent of non-Indian intermixture.

By degree of Indian ancestry

As might be expected, there is some association between age and degree of Indian Ancestry alleged. The mean age of the "pure" Indians is 27.8 years; of those who are more than half Indian 14.3 years; of those who are half-Indians 20.4; and of those who are less than half Indian it is 13.1. Nevertheless, a comparison between these various groups is of interest, and should assist in elucidating the sources of change in gene-frequency which are apparent among the people of the Hupa reservation. An examination of table VII shows a number of interesting differences between these sub-groups of the population. Gene-frequencies are not stated because none of these sub-groups may be regarded as a valid genetic isolate. All of the individuals alleged to be "pure" Indians are either Hupa or Hupa-Yurok in ancestry. It is notable that the blood-types A_2 B, R^0 and r do not exist in the group although the allele for R^0 or r must be present; that O and Duffy positives are overwhelmingly preponderant; and that R^2 is more common than R^1. The MN frequencies, however, are similar to those of the total group.

Individuals who are more than half Indian, but with some non-Indian ancestry acknowledged, number 83. Most of them are, so far as the records show, Hupa, but at least 10% claim Yurok ancestry as well, and Mexican and Sioux are also mentioned. It may be presumed that most of the other non-Hupa ancestry is Caucasian, but it is doubtful that all of such ancestry

TABLE 7

Blood-type frequencies, for persons of various degrees of Indian ancestry

	Phenotypic percentages			
	"Pure" Indian	More than half Indian	Half Indian	Less than half Indian
A_1	0.16	0.15	0.14	0.37
A_2	—	0.02	0.01	0.04
B	—	0.12	0.06	0.07
A_1B	—	0.01	0.01	0.01
O	0.84	0.69	0.78	0.51
M	0.36	0.47	0.34	0.38
MN	0.36	0.43	0.45	0.44
N	0.28	0.10	0.21	0.18
CDE	0.06	0.12	0.08	0.06
CcDE	0.36	0.23	0.20	0.20
cDE	0.30	0.14	0.20	0.13
CcDe	0.06	0.16	0.25	0.28
CDe	0.16	0.26	0.16	0.27
cDe	—	0.01	0.02	—
cde	—	0.01	0.04	0.02
CcDEe	0.03	0.04	0.03	0.01
cDEe	0.03	0.03	0.02	0.03
Fy(a+)	0.95	0.84	0.87	0.76
Fy(a−)	0.05	0.16	0.13	0.24

is. The alleles B and A_2 are both present in this sub-series. Seven of the 10 B phenotypes are concentrated in two sibships. The frequency of O has dropped considerably, and so has that of N, as contrasted to the "pure" Indians, the latter to a degree which closely approaches the 0.05 probability level, as tested by Chi-square, despite the small sizes of the two series. In the RH series, R^2 has replaced R^1 as the more common phenotype to a striking degree, nor is this to be accounted for by concentration in certain sibships. Both R^0 and r appear in this group, but it may be noted that none of the parents of either are listed as "pure" Indians. The frequency of Duffy negative is the same as for the entire sample drawn from the Hupa reservation.

Most of the Karok and nearly half of the Yurok are listed among those who are half Indian in ancestry, and so are a few individuals of tribally mixed ancestry. By far the greater number, however, are said to be half-Hupa. There are 131 persons in this category, and in a large number of cases they are F_1 hybrids between Hupa and Caucasian. The extent to which random fluctuation of gene-frequencies exists, among populations undergoing admixture, is illustrated by contrasting this group with the previous two. In most respects it is intermediate between the "pure" Indian group and that composed of persons who are more than half Indian. Indeed, the percentage of blood-type A_1 is less, even, than among the "pure" Indians. The MN series approximates the frequencies of the "pure" group, while the Duffy series resembles more closely the percentages found among those who were more than half Indian. Insofar as RH types are concerned, the alleles for R^1 and R^2 may be inferred to exist with almost equal frequency. However, the percentage of RH negatives is very considerably higher. In this respect, and possibly with respect to Duffy negative phenotypes, the group alleged to be half Indian resembles Caucasian frequencies to a greater extent than would a combination of the "pure" with the more-than-half Indian group. The accuracy of the classification by degree of Indian ancestry under the circumstances, would appear open to doubt: quite possibly some of those classified as more-than-half Indian are really nothing of the sort. As time goes on, not only have opportunities for miscegenation accumulated, but instances thereof in one's ancestry may be forgotten, and the average age of the more-than-half Indian group is very young.

These individuals classified as less than half Indian number 110. In contrast to the groups which are not "pure" Indian but are at least one half Indian in ancestry, they may be seen to possess a very much higher frequency of blood type A_1, a considerably higher frequency of A_2, but no greater frequency of B. The MN frequencies remain essentially unchanged, but the percentage of Duffy negative blood types show a sharp rise. In the RH series, there are a number of changes: the phenotypes R^z and r are found less frequently, and R^0 does not appear at all; R^2 decreases in percentage somewhat, while R^1 increases considerably. In general, the phenotypes to be expected from European ancestry become distinctly more common. This fact is reëmphasized by comparison of this last group to those who are alleged to be of purely Indian ancestry. The evidence would certainly indicate that the alleles A_2, B, and r were not aboriginal, and that the frequency of O, Fy^a, R^z and R^2 was very much higher in aboringinal times, in this part of California, than among Europeans. There does not appear to have been much difference between Europeans and the Hupa in relative frequency of M and N, and R^0 may well have been an aboriginal gene, although a rare one, as in Europe.

By tribal affiliation

Since by no means all of the Indian ancestry in this population is Hupa, some analysis on the basis of tribal affiliation is also required for a full understanding of the dynamics of gene-flow on the reservation. Data from each of the non-Hupa tribes is, however, so scanty that presentation in tabular form is not attempted.

Among those who are either "pure" or more than half Indian in ancestry, those who are more than half-Hupa number 89. They do not appear to differ from the remainder of the group in the frequency of the various alleles in ABO series, nor in the Duffy blood-types either. The Hupa have, however, a very much higher frequency of M than do the non-Hupa, and a Chi-square test shows that such a difference could be expected in much less than one case out of a hundred. The allele N is apparently concentrated among the Yurok. The number of Yurok is, however, too small to permit statistical validation of the significance of these data. In the RH series, the more-than-half Hupa cannot be distinguished from the other more-than-half Indians as a group.

Those who are half-Hupa, among those who are half-Indian in ancestry, also number 89. They resemble those who are more than half-Indians, in the ABO and Duffy series of blood-types, having a high gene-frequency of O and of Fy^a. The percentage of N among them, however, is sharply increased, which is not the case among the other half-Indians, as contrasted to the group with a greater amount of Indian ancestry. The Yurok, however, continue to be the tribe with the highest frequency of N, and also show a high percentage of Duffy negatives. In the RH series, the half-Hupa cannot be distinguished from the other half-Indians as a group.

Among those who are less than half-Indian, the differences between Hupa and non-Hupa become quite insignificant in all the series of blood-types tested. Indeed, in this group one finds an exceptionally high number of individuals who are of tribally mixed ancestry, so that the fact that tribal distinctions in gene-frequencies are reaching the vanishing point is only to be expected. Comparison of the various tribes has not revealed any notable difference between the Hupa and the others, save for the possibility of a higher aboriginal gene-frequency for N and for Duffy negatives among the Yurok.

DISCUSSION

The three types of analysis undertaken demonstrate clearly that some new alleles have, within the last few generations, been introduced into the aboriginal population of northwestern California, and that some others, already present in small quantity, have altered in incidence to a considerable extent, but that the alleles at the MN locus show no signs of change in relative frequency. It has not been possible to demonstrate that the changes which are taking place are due to intertribal matings. The younger generation appears to differ from the older to about the same extent that the more mixed differ from the less mixed at the RH locus but the effects of alleged degree of intermixture appear to count for most at the ABO and at the Duffy loci. The younger generation, furthermore, shows a slight deficiency in such heterozygous phenotypes as could be demonstrated by the sera available.

Studies of Sioux (Snyder, '26; Matson, '41), Chippewa (Matson, '54), and Cherokee (Pollitzer, personal communication) blood-type frequencies would have led to the expectation that intermixture of these tribes with the Hupa should result in alteration of blood-type frequencies, if our small group of "pure" Indians are indeed representative of their ancestral stock, since they differ markdly from the Hupa at the MN, RH and Duffy loci, although not at the ABO. However, the specific individuals from these tribes who came to live among the Hupa do not, in fact, form a representative sample: all of them, without exception, were of mixed ancestry in any case. It is well to remember that when a relatively small number of individuals from one population are selected at random, they may not be representative: the specific Caucasians who have intermarried among the Hupa may not be, either. Indeed, a number of the geneologies show this to be the case.

Furthermore, some kindreds, at any given period of time, will be much more numerous than others. Among the oldest individuals who were typed, some have no living grandchildren at all, but one pair have 8 children living, of whom two were typed; 7 of these children have produced at least 29 members of the third generation of whom 20 were typed. Thus, even with intermixture at a minimum, shifts in allelic frequency may readily occur because of differential fertility, or on the other hand, the anticipated effects of intermixture may be counteracted by the greater fecundity of unaffected family lines. In the particular prolific family just mentioned, marriage outside the group would appear to be the rule: Grandfather is half Welsh and half Karok, Grandmother half-Hupa. One of their offspring married a Sioux, another a Mexican, a third a Hindu, a fourth a Portuguese, a fifth a Yurok, and a sixth a Caucasian. None of the grandchildren had started to reproduce at the time of the survey.

In fact, an examination of the various kindreds included in the sample makes it clear that the more prolific tend almost always to be those among whom inter-tribal if not inter-racial marriages are very frequent. Nine sibships of schoolchildren alleged to be pure Indian contain only 21 individuals, of whom 16 were typed. Thus the two forces which might be expected to lead to a shift in allelic frequencies, drift and miscegenation, appear to be acting in unison on the Hupa Reservation, rather than counteracting one another, at least during the present generation. We have no evidence, of course, which would enable us to state that this was so during the last century.

Nor do we know for how long a period the Hupa have been exchanging genes with their neighbors, the Yurok and Karok. During the present century marriages between these groups have, according to the data collected in connection with the blood-typing survey, been not at all uncommon. But the lack of statistically significant differences between the three groups, in blood-type allele frequencies, may as well be due to the inadequacy of the samples which we were able to collect from the Yurok and Karok, as to long continued interbreeding. Propinquity gives opportunity, but not always incentive, to marriage between neighboring groups. It can only be said that the data do not deny the likelihood of extensive intermixture in earlier times.

Since there is no genetic linkage between the 4 sets of blood types which provide the data for this study, correlations between any two or more of them, if statistically significant, would have to be explained as due to some non-genetic factor. Preferential mating, for instance, might lead to such an association, even although the individuals concerned were unaware of the existence of blood types, under certain circumstances. Thus the allele R^0 has no greater incidence among United States Caucasians than among European Caucasians, although the geographic propinquity of potential mates with type R^0 is very much greater in the United States. The same is true of the gene for sickle-cell; and there is in consequence, in the United States, a correlation between R^0 and sickle-cell despite their lack of linkage. With the thought that this might be true on the Hupa reservation, and the "pure" Hupa might prefer other "pure" Hupa as spouses, while near-Caucasians might prefer near-Caucasians, the extent of association between blood-type O and M, between O and Duffy positive, and between O and several phenotypes of the RH series was studied. The results, as tested by Chi-square, were completely negative except in the case of Duffy, in which the deviation from expectation reaches the 0.04 level of probability. An inspection of the data showed that of the 28 individuals tested for Duffy who have phenotypes A_2, B, or AB, 10 were Duffy negative. It seems reasonably clear that these two separate genetic items have to some extent been introduced jointly, and have not yet had time to become disassociated through mating which is random for these factors. It was also found that the Duffy negative phenotype is associated with the phenotype N, the deviation from expectation, on the assumption of random assortment, reaching the 0.05 level of probability. There is, however, no association between N on the one hand, and A_2, B or AB on the other. This seems to be due to the high frequency of both N, and Duffy negative in the small series of Yurok, and leads to the conclusion that the latter allele has been entering the Hupa gene-pool from two sources: their long-time neighbors the Yurok, and individuals of transatlantic ancestry.

No associations could be established between relative allele frequencies in the RH series, and either Duffy or MN. Thus, preferential mating of a sort which might affect the distribution of blood-types among the Indians on the Hupa reservation has clearly been minimal, and it should be safe to predict that within another generation the association between Duffy negative on the one hand, and A_2

B, AB and N on the other hand, will have vanished also.

It will be recalled that there is a slight deficiency in observable heterozygotes among the younger generation, at all three loci where this could be tested. Only in the case of MN did this deviation approach the point of statistical significance, but it is remarkable that the deviation from the expectation of genetic equilibrium is in the same direction in all three cases. No such situation exists in any of the groups having varying degrees of Indian ancestry, nor are any of these deficiencies concentrated in any one tribe which is contributing to the gene-pool. It appears to be purely a matter of age, and no explanation is attempted.

In attempting to reconstruct aboriginal gene-frequencies for the Hupa, Yurok and Karok, certain cautions must be observed. The genetic contributions of other Indians, as well as of individuals from overseas, must be excluded. Fortunately, age trends agree with the trends observed in comparing groups of varied degrees of Indian ancestry, and fortunately too, all who are alleged to be "pure" Indian are either Hupa, Yurok, or mixture between the two. The effects of differential fertility in different kindreds cannot be calculated, but it must be recognized that, in aboriginal days as well as now, some individuals would have left more offspring than did others. Gene frequencies may well have fluctuated back and forth from generation to generation; or, in a breeding population of such restricted size, have drifted constantly in a single direction.

With these cautions taken into account, it is still possible to say that, in aboriginal times, the alleles A_2, B and r were not to be found among the Hupa, Yurok and Karok; that A_1 was rare; that N and Fy^b were in a distinct minority—although perhaps a larger minority among the Yurok—that R^z certainly, and R^0 quite probably did exist, and that R^2 was probably at least as frequent an allele as R^1, and perhaps even more frequent.

No information is available concerning the serology of any tribe of Indians living nearby. Athapaskan-speaking peoples have been typed, however, both in Canada and in the Southwest (Grant, '36, '38; Allen, '35; Chown, '54, '55; Boyd, '49; Ikin, '52; Kraus, '56; Brown, '58). A variety of tribes living in Washington and British Columbia have also been studied (Chown, '52; Hulse, '55, '58; Gates, '32; Ride, '35). Comparison with other Athapaskan tribes shows that the Hupa have a greater incidence of blood-group O than any other people of the same linguistic stock. Most Athapaskans have a higher frequency of A than their neighbors, but we are unable to say this of the Hupa. Rather, in their very low incidence of A, the Hupa-Yurok-Karok group resemble such other Pacific Coast people as the Nootka and Coast Salish to the north and the Diegeño in Southern California (Pantin, '53). The high incidence of R^2, and the existence of R^z are other points of similarity between these Indians of northwestern California and the Indians several hundred miles further north along the coast (Hulse, '55, '57; Mourant, '54). The allele R^z appears to be found among all other Athapaskan tribes so far published, except for the Sarcee (Chown, '55), in frequency close to that estimated for the Hupa. The allele R^2, however, is rarely found to be as frequent as R^1. Except for some of the Indian tribes in British Columbia and Washington, the Chippewa (Maston, '53) and the Carrier (Chown, '54) appear to be the only other tribes yet published of whom this is true, although in most American Indian tribes this allele has a much higher incidence than elsewhere in the world. The suspected presence of R^0 is reminiscent of other Athapaskan groups, since it has been determined by test, or genetically inferred for the Apache (Kraus, '56), the Navajo (Boyd, '49; Ikin, '52), and the Sarcee (Chown, '55). In all cases, including the present, the strong possibility of its introduction by means of admixture with Africans cannot be ruled out. Until recently it was the opinion of the author that the presence of this gene could always be taken as an indication of African admixture, but in fact it does appear more frequently among Athapaskans than among other tribes, and is found also in the plateau area which separates the Pacific Coast Athapaskans from their Canadian cousins (Hulse, '57).

In the MN locus, there is the possibility that the Yurok and the Hupa differed in aboriginal times. In any case, the incidence of the allele N is remarkably high for an American Indian group; indeed only a few Arizona populations (Brown et al., '58) approach them in this characteristic, although there is a considerable degree of intertribal variation. At the Duffy locus, too, the Indians of northwestern California appear to be rather distinctive, and in this case also one may suspect that the Yurok rather than the Hupa are responsible. The allele Fy^b has been inferred to exist in relatively high frequency among the Yakima (Hulse, '57), the Diegeno (Pantin and Kallsen, '53), the Stoney (Chown, '55), and the Cherokee (Pollitzer, '59), and in extraordinarily high frequency among the Pima, Mescalero (Brown et al., '58), and Brazilians (Pantin and Junqueira, '52). Aside from this remarkably scattered group, American Indian tribes appear to have a low incidence of this allele. The significance if any, of the geographical distribution of these exceptions from the general rule of low incidence for N and Fy^b among American Indians remains obscure, at least to the author.

Certainly one cannot maintain that the Hupa resemble, in their blood-type frequencies, the other Athapaskans. Both the author (Hulse, '57) and others (Brown et al., '58) have suggested that Athapaskans, who have typically been organized in simple bands, living a hunting-fishing-gathering life, and who are generally supposed to have been the most recent pre-Columbian migrants into the New World, appear to be genetically distinct from their neighbors at the various blood-type loci. Lacking adequate samples of neighboring tribes in northwestern California, we cannot test this proposition for the Hupa. Since, however, they diverge so sharply from other Athapaskans, and resemble, rather, other Pacific Coastal peoples, it would seem unlikely that they could be fitted into any such scheme. Rather, one suspects, the influence of Northwest Coast culture, even in its attenuated form, led to such extensive and long continued intermarriage that the original Hupa gene-pool merged into another, larger one long ago.

Today, the same sort of process is being repeated on a larger scale. Under the impact of Western or European culture, the Indians of Northwestern California are selecting their spouses for new reasons, and from a much wider range of populations. Indians of other tribes are engaged in European style occupations, such as lumberjack and paper mill worker, which lead them to settle in the Hupa reservation. New genes flow in from all directions, setting up ripples in a gene pool which had previously been calm. It may be that equilibrium will be regained in the next generation. There is no evidence to suggest that the infusion of new alleles is about to cease, however, so that we might be wiser to suspect that the calm equilibrium of this gene pool is a thing of the past, and that the rippling will continue.

LITERATURE CITED

Allen, F. W., and W. Schaeffer 1935 The distribution of the human blood groups among the Navaho and Pueblo Indians of the Southwest. Univ. New Mexico, Bull. Biol., series IV, no. 2: 2–29.

Boyd, W. C. 1939 Blood groups. Tabulae Biologicae, *18:* (part 2) 113–240.

Boyd, W. C., and L. G. Boyd 1949 The Blood groups and types of the Ramah Navaho. Am. J. Phys. Anthrop., *7:* 569–575.

Brown, K. S., B. L. Hannah, A. A. Dahlberg and H. H. Strandskov 1958 The distribution of blood group alleles among Indians of southwest North America. Am. J. Human Genet., *10:* 175–195.

Chown, B. 1954 Personal communication.

Chown, B., and M. Lewis 1955 The blood group and the secretor genes of the Stoney and Sarcee Indians of Alberta, Canada. Am. J. Phys. Anthrop., *13:* 181–190.

Gates, R., and G. E. Darby 1934 Blood groups and physiognomy of British Columbia Coastal Indians. J. Roy. Anthrop. Inst., 64CD: 23–44.

Gates, R. 1929 Blood groups of Canadian Indians and Eskimos. Am. J. Phys. Anthrop., *12:* 475.

Grant, J. C. B. 1938 Anthropometry of the Beaver, Sekani and Carrier. Nat. Mus. Canada, Bull. 81, Anthrop. ser. no. 18:1–37.

Hoijer, H. 1956 The chronology of the Athapaskan Languages, Inst. J. Am. Ling., *22:* 219–232.

Hulse, F. S. 1955 Blood types and mating patterns among Northwest Coast Indians. Southwest J. Anthrop., *11:* 93–104.

——— 1957 Linguistic barriers to gene-flow. The blood groups of the Yakima, Okanagon and Swinomish Indians. Am. J. Phys. Anthrop., *15:* 235–246.

Hymes, D. H. 1957 A note on Athapaskan glottochronology. Inst. J. Am. Ling. *23:* 291–297.

Ikin, E. W., and A. E. Mourant 1952 Unpublished observations.

Kraus, B. S., and C. B. White 1956 Microevolution in a human population. Am. Anthrop., *58:* 1017–1043.

Kroeber, A. E. 1925 Handbook of the Indians of California. Bull. Bur. Am. Ethnol., p. 78.

Matson, G. A. 1941 Distribution of Blood Groups among the Sioux, Omaha and Winnebago Indians. Am. J. Phys. Anthrop., *28:* 313–318.

Matson, G. A., E. Koch and P. Levine 1954 A study of the hereditary blood factors among the Chippewa Indians of Minnesota. Ibid., *12:* 413–426.

Mourant, A. E. 1954 The distribution of the human blood groups. Blackwell Scientific Publications, Oxford.

Pantin, A. M., and P. C. Junqueira 1952 Blood groups of Brazilian Indians. Am. J. Phys. Anthrop., *10:* 395–405.

Pantin, A. M., and R. Kallsen 1953 The blood groups of the Diegeno Indians. Ibid., *11:* 91–96.

Pollitzer, W. S. 1959 Personal communication.

Ride, L., and I. Furuhata 1935 Anthropological Studies amongst North American Indians from British Columbia. Caduceus, *14.*

Salzano, F. 1957 The blood groups of South American Indians. Am. J. Phys. Anthrop. *15:* 555–580.

Snyder, L. 1926 Human Blood Groups: their inheritance and racial significance. Ibid., *9:* 233–263.

BRIEF COMMUNICATION

Skeletal Evidence of Speech?

E. LLOYD DuBRUL AND CHARLES A. REED
*Chicago Professional Colleges, University of Illinois,
Chicago, Illinois*

During the third session, "Man as an Organism," of the recent (November, 1959) Darwin Centennial Celebration at The University of Chicago, the old question again arose as to whether this or that hominid represented by a fragmented fossil skull, had the habit of speech.[1] Dr. L. S. B. Leakey spoke of speech and australopithecines deciding that, when he could find no evidence of scars for the attachment of tongue muscles on a fossil jaw (genial tubercles, i.e., spinae mentales), the beast could not speak.

This notion is found written explicitly by von Koenigswald in "Meeting Prehistoric Man" ('56, p. 112). But even further, von Koenigswald has specifically tied two separate ideas together; speech as determined by the presence of genial tubercles (he called them "indispensable"), with speech as determined by the presence of a "speech center" in the inferior frontal convolution of the brain (Broca's area). He wrote of a jaw fragment with the symphysis missing: "we must assume the tubercle's existence—a fair development of the speech centre, which is localized in the third left frontal convolution, *is clearly visible in the brain-cast*" (italics ours).

Von Koenigswald (in personal correspondence with Reed) based his statements on Hooton, "Up from the Ape" ('46, p. 169). "These spines of bones are called the genial tubercles and are found only in man. The presence of well-developed genial tubercles is the surest anatomical evidence of articulate speech that the skeleton affords." However, in the next sentence Hooton continued, "But a poor development of these bony spines to which the tongue muscles are attached is no evidence at all that the possessor is or was unable to speak." He goes on to say that he ". . . has examined hundreds of human mandibles in which the genial tubercles are very small and *not a few in which they were absent;* but probably none of the original owners of these jaws was dumb, and many of them may have been extremely loquacious," (again italics ours). Even as far back as 1915, Thomson had shown conclusively that these tubercles are "frequently absent" in normal modern jaws.

In the same session (Man as an Organism) when the question of brain structure and speech arose, Dr. B. Rensch said that language depends on an area in the frontal lobes. Referring to the fossils, he said that this area was pre-adapted to become a "speech center" and that it had been enlarged by quantitative steps of mutation. He added casually that everybody knows what is meant by the "speech center." But we think some of us do not.

The problem of brain capabilities as determined from endocranial casts of fossils is as old as is the business of bony bumps on the jaw. It has been assumed by many paleoanthropologists that the presence of "Broca's area" demonstrates the possession of speech. In 1946 (p.253) Schepers wrote of the endocranial casts of australopithecines: "Broca's area has been differentiated in man as the primary motoric speech area. . . . But the immediately adjacent cortices in the orbital insular operculum probably control the associated secondary mechanisms to a certain extent. These areas are present in our fossil endocranial casts." Although Schepers seemed aware that less immediate associations are implicated, he could still conclude: "The least we can say, therefore, is that these fossil types . . . were also capable of communicating the acquired information to their families, friends and neighbors, thus establishing one of the first bonds of man's complex social life."

---

[1] By speech we mean the special mode of oral communication used by man. "The physical event of speech is a pulse of discrete, vibrating, jointed segments of air" (DuBrul, '58) that conveys information. This is not mere vocalization.

Now, part of the misunderstanding may come from speaking of endocranial casts as "brain casts." Again as early as 1915, Symington questioned the reliability of casts in determining even the grossest of cortical morphology. He studied the endocranial casts of 10 skulls whose brains he had preserved, noting that "In no single instance do these fissures correspond to definite depressions indicating their position, and very frequently, in various parts of their course, *they lie over eminences of the cast* (again italics ours). His unequivocal conclusions are:

"1. That the simplicity or complexity of the cerebral fissures and convolutions cannot be determined with any degree of accuracy from endocranial casts, even on complete skulls, much less on reconstructions from imperfect skulls.

2. That it is not possible to estimate, even approximately, from the La Chapelle or Piltdown endocranial cast, the relative degree of development of the various sensory and association centres in the cortex.

3. That the various deductions made by Boule, Anthony, Elliot Smith, and others, with reference to the primitive and simian features of the brains of certain prehistoric men, from an examination of their endocranial casts, are highly speculative and fallacious."

At last the Piltdown skull can be put to good use for one can no longer doubt the above conclusions after reading the spate of speculation on its "primitive" features that came from taking its "brain casts" too seriously.

But right to the point is the story of "Broca's area" itself. In 1861 Paris was the center of neurology and anthropology. Several distinguished figures of the time played active parts in our play. Paul Broca was 37. He was secretary of the Societè d'Anthropologie which he had founded and which was the first Anthropological Society in Europe. He was o the surgical service of the Bicêtre but wa not yet professor. Charcot, the famou teacher of Freud, was about a yea younger than Broca. He had a service a the Salpêtrière, the insane asylum o Paris. Bouillaud was professor of medicine at the Charité and had several time been dean of the faculty. He was 65 the recipient of many honors and perhap the most influential physician on th scene. Furthermore, the general influenc of Franz Joseph Gall on neurology wa still considerable, even though his phrenological "system" had been mostly discarded. Especially was the elderly Bouillaud saturated with Gall's scheme of discrete localization of function—vide th title of his much cited paper of 1825 "Clinical researches calculated to demonstrate that the loss of speech is associated with a lesion of the anterior lobes of th brain, and to confirm the opinion of Monsieur Gall on the seat of the organ o articulate language" (authors' translation).

At a meeting of the anthropologica society on April 4, 1861, a heated discussion of these concepts arose. Aubertin, member of Bouillaud's staff, felt so certai of the position of Gall (and his own chief that he announced that if he could b shown but a single case in which a patient had lost the ability to speak and i which no lesion could be demonstrate in the frontal cerebral lobes, he woul willingly discard these notions. Broca wa a highly interested, but apparently neutral, member at the meeting.

Less than a week later, April 11, a ver sick 50-year-old aphasic patient was admitted to Broca's service at the Bicêtre Broca immediately invited Aubertin examine the patient so that he could decide if this would be an acceptable te case. Aubertin agreed that it was qui satisfactory. On April 17, the patient (L borgne) died. The next day, April 1 Broca presented the brain to the anthropological society. A lesion of the inferi frontal convolution on the left side wa clearly visible. Although other lesion were present Broca decided, on what appeared good grounds, that the critical l ion was that of the frontal lobe. From the case history, he concluded that the oldest part of the lesion was correlated with the time of onset of aphasia. After a second such autopsy (case of Lelong), Broca came to the conclusion that the left inferior frontal convolution was the "center of speech." This was published in November 1861 in the Bulletins de la Société Anatomique.

But the true climax came 45 years late. Pierre Marie, who had served his internship under Broca, was now professor of the Faculty of Medicine of Paris. He was highly interested in the problem of aphasia and, on the basis of observations on about a hundred patients followed up by some fifty autopsies, he reviewed the problem of the localization of speech. Fortunately, he found the brains of Broca's two cases in the Musée Dupuytren (no. 56 and no. 60 of the nervous system collection). They were in an excellent state of preservation.

In an article in 1906 he reported that, in the first case, only the posterior half of "Broca's area" showed "softening," but the lesion was (as Broca had noted) extensive. "Destruction of third frontal (convolution) in its posterior half. Destruction of rolandic convolutions in their inferior halves. Destruction of first temporal in most of its extent but especially in its anterior half. The foot (base) of first temporal is equally affected by the softening at the level of the posterior extremity of the fissure of Sylvius around which the lesion turns. The supramarginal gyrus is destroyed to a notable extent" (authors' free translation). The second case, Marie felt was probably not even a true aphasic. He thought that the patient might merely be senile at the age of 84. Not only were the lesions in this case inconclusive—the general changes of senility—but Marie stated that the clinical histories in both cases were second hand. Neither patient was in quite the condition to answer questions sensibly.

Marie respectfully honored his old teacher, pointing out that the conceptual milieu of Broca's time might be expected to generate such conclusions.[2] In the same paper he quoted Broca's own doubts as influenced by observations of Charcot. "I have been able to ask myself if the seat of the faculty of articulate language, *instead of being localized exclusively in the posterior part of the third frontal convolution, does not also extend to the external parietal convolution*" (these italics are Marie's).

It seems anticlimatic to cite the results of mapping speech with modern neurosurgical techniques (Penfield and Roberts, '59). The speech *"areas"* evident from electrical stimulation include, for the inferior frontal convolution, *only its middle third*, but further include an area on the superior and *medial* side of the cerebral hemisphere just anterior to the precentral gyrus (which endocranial casts cannot even reach), the supramarginal gyrus of the parietal lobe, the posterior third of the superior temporal gyrus, the posterior half of the middle temporal gyrus, and even the upper part of the posterior half of the inferior temporal gyrus. This is the mapping of the dominant, usually left, hemisphere but function in part may be taken over by the other hemisphere in case of damage to the dominant side.

Then, not only are endocranial casts not reliable replicas of brainy bulges, but surface contours, even if they could be reproduced, would not tell us what some students of human evolution have thought they did. And, although these erroneous ideas about jaws and brains have been pointed out from time to time by writers not all cited here, we are not merely flogging a dead horse. Apparently he is still kicking about in scientific conversation, in the literature, and in men's minds—we still see on pages 137 and 251 of Boule and Vallois' "Fossil Men" ('57) that the swelling of "Broca's convolution" indicating the probability of speech, seems an idea acceptable to them.

---

[2] Here it seems necessary to comment on a recent reference to this matter. On page 8 of "The Cerebral Cortex" (G. von Bonin, '50), it is said that Broca's specimens were "not even stripped of their membranes." We could not find any statement of Marie to this effect. The only mention of the matter states that the brains could be completely studied "car aucun section n'a été pratiquée dans leur épaisseur" which we translate freely as "for no dissection in their depth (thickness) was made."

We hope that part of the value of this note is in the telling of the story all in one piece and as a reminder that there remain always, traditional influences—such as harrassed so brilliant a scientist as Broca—to befog crucial issues.

But speech *does* require peripheral transducers; it is too naive to say "it is all in the head" when one means merely the cortex. And it does seem perfectly sensible to look for structural evidence of speech, both in peripheral areas (i.e., the throat, mouth, and jaws), and in central regions (i.e., the brain, by which is meant certainly more than cortex).

It has been shown that in peripheral areas the jaws have been shrunk in size, pulled back and remodelled primarily by the over-all mechanical demands of balancing the head in the upright posture. The formation of the genial tubercles is a minor event—a remnant of the scalloping out of the simian shelf to leave room for the anterior organs of the neck crowded by the retruded mandible (DuBrul and Sicher, '54).

Other relations are more crucial for speech. All mammals have larynges but, in most, the larynx protrudes through a "palatal additus" into the back part of the nose. Air blown through these rigid bony nasal channels cannot be chewed up into the articulated (i.e., jointed) segments of "articulate speech." Only those animals whose larynx has completely free access to a mobile oral space can possibly make "speech" sounds—birds and man (DuBrul, '58). Just the fact that the larynx has this position does not mean that an animal habitually speaks. But it does mean that *only then* is proper sound molding possible.

As for central regions, this must mean more than the cortex which seems but to sink the old fashioned phrenology a few millimeters deeper. Thalamocortical circularity is most certainly critical and the linking of all these neural circuits in special ways with lower order neurons i quite an essential part of the pictur (DuBrul, in press).

Skeletal evidence from fossils is sti the most direct and "noiseless" channe of communication from life in the pas It will certainly yield more reliable information when decoded in the light of functional comparative anatomy of livin structure. This in turn must feed bac a better grasp on present form and function. So, though we may not yet kno skeletal structures that we can surely associate with speech, it seems quite hopeful that they can be derived.

LITERATURE CITED

Boule, M., and H. V. Vallois 1957 Fossil Me The Dryden Press, New York.

Broca, P. 1861 Nouvelle observation d'aphémi produite par une lésion de la moitié postérieu des deuxième et troisième circonvolution frontales. Bull. Soc. Anatom. Paris, 6: (serie 2) 398–407.

DuBrul, E. L. 1958 Evolution of the Speec Apparatus. Chas. C Thomas, Springfield.

——— 1960 Structural evidence in the brai for a theory of the evolution of behavio Perspectives in Biology & Medicine, in press

DuBrul, E. L., and H. Sicher 1954 The Adap ive Chin. Chas. C Thomas, Springfield.

Hooton, E. A. 1946 Up From the Ape, 2nd e The Macmillan Company, New York.

Marie, P. 1906 Revision de la´ question d l'aphasie; l'aphasie de 1861 á 1866; essai d critique historique sur la genèse de la doctrin de Broca. Sem. Méd., Paris, 26: 565–571.

Penfield, W., and L. Roberts 1955 Speech an Brain-Mechanisms. Princeton University Press Princeton.

Schepers, G. W. H. 1946 The endocrania casts of the South African ape-men. Transvaal Mus., Mem. No. 2, 154–272.

Symington, J. 1915 Endocranial casts an brain form: A criticism of some recent speculations. J. Anat. Physiol., 50: 111–130.

Thomson, A. 1915 On the presence of genia tubercles on the mandible of man, and the suggested association with the faculty c speech. Ibid., 50: 39–74.

von Bonin, G. 1950 Essay on the Cerebra Cortex. Chas. C. Thomas, Springfield.

von Koenigswald, G. H. R. 1956 Meeting Prehistoric Man. Harper & Brothers, New York.

Book Review

THE SKELETAL REMAINS OF BAMBANDYANALO. By Alexander Galloway. Edited by Phillip V. Tobias, who contributes the Epilogue. Foreword by Raymond A. Dart. xxii + 154 pp. Price £ 2. Witwatersrand University Press, Johannesburg. 1959.

Bambandyanalo Hill is situated on the western side of the valley and about 500 yards south from Mapungubwe Hill in the Transvaal where the Shashi River, that divides Bechuanaland from Southern Rhodesia, enters the Limpopo. Mapungubwe, the hill of the jackals, will be remembered as the site from which the skeletal remains of eleven individuals were recovered together with a rich assortment of cultural materials. The report, beautifully published by the Cambridge University Press in 1937 under the editorship of the late Professor Leo Fouché, *Mapungubwe: Ancient Bantu Civilization on the Limpopo*, contained a description and analysis of the skeletal remains by Dr. Alexander Galloway. In this section of the work Galloway concluded that the skeletal remains had little, if any, Negro affinities, but presented a combination of two distinct pre-Negro physical South African types, Bush and Boskop. This conclusion was somewhat surprising in view of the fact that the cultural remains were unequivocally clearly those of a Bantu-speaking people.

Captain G. A. Gardner was responsible for the excavation of the site K2 adjoining Bambandyanalo Hill, and the skeletal remains of 37 individuals recovered up to 1936 by him form the subject of the present report. Gardner continued his excavations for 6 years, up to 1940, and succeeded in unearthing 74 more skeletons of all ages and both sexes. "The ceremonial interments" he writes, "were totally different to any known Bantu burials: they were exactly similar to pre-dynastic inhumations such as I had seen in Egypt, the body being partly or fully flexed and pottery either whole or deliberately broken, placed around the corpse." These interesting remarks are complemented by Galloway's finding that there is not a single specifically Negro feature in any of the skulls hitherto recovered at K2, and that "The K2 people are thus true representatives of a pre-Negro indigenous people, with which the Bantu-speaking Negro peoples had never hybridized." Clay figurines found at the site of the female form show elongated labia minora and steatopygia, strongly suggesting the Bush-Boskop type. Galloway's careful analysis of the skeletal remains were those of a Bush-Boskop type—essentially the same type as that found at Mapungubwe.

Carbon 14 dates for Bambandyanalo (K2) are 1055 A.D. ± 65 and for Mapungubwe 1370 ± 60.

Galloway completed the present work in 1937. To bring it up-to-date Tobias has contributed an epilogue "Some Developments in South African Physical Anthropology 1938–1958" (pp. 129–154). In this section Tobias places the findings of Galloway in the context of the discoveries made during the 20 years since his work was completed. What emerges from this extremely interesting epilogue is that the Bush-Boskop was widely distributed over South Africa, and in many parts of that land represents a pre-Negro population. Tobias has an excellent discussion of the whole "Boskop question," as it may be called, and there are interesting discussions of neoteny, pedomorphism, gerontomorphism, and sexual dimorphism in the expression of racial type. Tobias confuses sex-influenced traits with sex-limited traits, but this is of no great moment, for this is a matter upon which many professional geneticists are unclear. Altogether, this is a most stimulating epilogue to an altogether most informative and stimulating work.

Ashley Montagu
Princeton, N. J.

BOOKS RECEIVED

A Century of Darwin edited by S. A. Barnett. 1958. $5.75. Harvard University Press, Cambridge.

An Introduction to Anthropology by R. L. Beals and H. Hoijer. 2nd edition. 1959. $6.90. Macmillan Company, New York.

Principles of Self-Damage by Edmund Bergler. $6.00. Philosophical Library, New York.

Tribes of the Sahara by Lloyd C. Briggs. 1960. $6.00. Harvard University Press, Cambridge.

Contributions to the Physical Anthropology of the Soviet Union; Russian Translation Series of the Peabody Museum of Archaeology and Ethnology by V. V. Bunak, G. F. Debets and M. G. Levin. Volume 1, No. 2. 1960. $4.50. The Peabody Museum, Harvard University, Cambridge.

Recent Advances in Neuro-Physiological Research edited by D. E. Cameron and Milton Greenblat. 1959. American Psychiatric Association, Washington.

The Antecedents of Man by Sir W. E. LeGros Clark. 1960 $6.00. Quadrangle, Chicago.

Soils for the Archaeologist by I. W. Cornwall. 1958. $7.50. Macmillan Co., New York.

Dictionary of Education by John Dewey. 1959. $3.75. Philosophical Library, New York.

Runes, an Introduction by R. W. V. Elliott. 1959. $10.00. Philosophical Library, New York.

Recherches sur l'Anthropologie des Françaises by Suzanne deFelice. 1958. 3,000 francs. Masson and Company Paris.

A Brief Dictionary of American Supersititions by Vergillius Ferm. 1959. $6.00. Philosophical Library, New York.

The Skeletal Remains of Banbandyanalo by Alexander Galloway. 1959. Witwatersrand University Press, Johannesburg.

Anatomy by Ernest Gardner, Donald J. Gray and Ronan O'Rahilly. 1960. $15.00. Saunders, Philadelphia.

The Death of Adam by J. C. Green. 1959. $4.95. Iowa State College, Ames.

Nature and Man's Fate by Garrett Hardin. 1959. $6.00. Rinehart and Company, New York.

The Anatomy of Callimico Goeldii by W. C. Osman Hill. 1959. $2.50. American Philosophical Society, Philadelphia.

Human Evolution: Readings in Physical Anthropology edited by N. Korn and H. R. Smith. 1959. $5.50. Henry Holt and Company, New York.

A Symposium on the Chemical Basis of Development edited by William D. McElroy and Bentley Glass. 1958. $15.00. The Johns Hopkins Press, Baltimore.

Races and Cultures of India by D. N. Majumdar. 1958. 22.50 rupees. Asia Publishing House, Bombay.

Inner Conflict and Defense by Daniel R. Miller and Guy E. Swanson. 1960. $6.95. Henry Holt and Company, New York.

Evolution and Christian Thought Today edited by Russel L. Mixter. 1959. $4.50. William B. Eerdmans Publishing Company, Grand Rapids.

Pratique Anthropologique by Georges Olivier. 32.40 N. francs. 1960. Vigot Fréres, Paris.

Child Development by W. C. Olson. 1959. Heath and Company, Boston.

Man's Journey Through Time by L. S. Palmer. 1959. Philosophical Library, New York.

Outline of Human Genetics by L. S. Penrose. 1959. $2.50. Wiley, New York.

Behavior and Evolution edited by Ann Roe and G. G. Simpson. 1958. $10.00. Yale University Press, New Haven.

Anthropologia Helvetica II. Die Anthropologie der Kantone und der Natürlichen Landschaften. 1959. Art. Institut Orell Fussl A/G., Zurich.

Advances in Clinical Chemistry edited by Harry Sobotka and C. P. Stewart. Volume I. 1958. $12.00. Academic Press, New York.

Dictionary of the American Indian by John Stoutenburgh, Jr. 1960. $10.00. Philosophical Library, New York.

The Birth of Normal Babies by Lyon P. Strean. 1958. $3.95. Twayne, New York.

Some Papers on the Cerebral Cortex translated by G. von Bonin. 1960. $11.50. Charles C Thomas, Springfield.

The Dover Mound by W. S. Webb and C. E. Snow. 1959. The University of Kentucky Press, Lexington.

The Distribution of Several Blood Group Genes in Liberia, the Ivory Coast and Upper Volta[1]

FRANK B. LIVINGSTONE,[2] HENRY GERSHOWITZ, JAMES V. NEEL,
WOLF W. ZUELZER AND MARVIN D. SOLOMON
*Department of Human Genetics, University of Michigan Medical School,
Ann Arbor, Michigan, Child Research Center of Michigan, Detroit
Michigan, and Department of Natural Sciences, Michigan
State University, East Lansing, Michigan*[3]

The cline for the sickle cell gene which has been demonstrated in Liberia (Livingstone, '58a) is one of the most striking in human genetics. From a high of a gene frequency of about 0.10 in northwestern Liberia, the frequency falls to essentially zero in southeastern Liberia and the adjacent Ivory Coast. During the past four years, in conjunction with the survey of the distribution of abnormal hemoglobins which led to the demonstration of this cline, we have tested 2695 West African blood samples for various red cell antigens. All of the samples were tested with ABO, MN, and CDE anti-sera, while smaller numbers were tested for the presence of the following antigens: A_1 and A_2; c, C^w, D^u, and e; K and k; Fy^a; Di^a; He; U; P; Jk^a; and Tj^a. Determinations of the serum haptoglobin types were also performed on 614 specimens. In addition to the fact that these tests are, with the exception of the ABO blood groups, the first to be reported for these antigens on the tribes of this part of West Africa and so fill a gap in existing knowledge of the blood group gene distributions, this study has provided an unusual opportunity to test for the occurrence in 12 different genetic systems of clines parallel to the sickle cell gene cline. The findings to be described are thus thought to further our understanding of the dynamics of the sickle cell gene.

METHODS

The majority of the blood samples were collected in 10 ml "Venules" containing oxalate as an anti-coagulant, but 218 specimens in which the blood was permitted to clot were also included in the survey. The samples were kept under refrigeration until air-shipped in ice-packed thermos jugs to the United States. In general the blood was typed about one week to 10 days after collection, although some shipments were typed as late as three weeks after collection.

Procedures at Child Research Center. In 1955–56 the samples were tested at the Blood Grouping Laboratory of the Child Research Center of Michigan. All samples were tested *once* with a commercial antiserum for the presence of the following antigens: A and B; C, D, and E; M and N. Three per cent cell suspensions were used throughout. The A-B determinations were slide-typings, agitated for 5 minutes, after which the results were read grossly, but weak reactions were checked microscopically. For the MN determinations, immune rabbit sera were used. One drop of antiserum was added to a drop of the cell suspension in a test tube, and the results read with a mirror after 15 minutes at room temperature. The Rh determinations involved one drop of the appropriate antiserum and a like amount of cell suspension, incubated at 37° for one hour, then centrifuged for one minute at 2500 rpm in a clinical centrifuge, and the results read grossly with the aid of a concave mirror.

Procedures at Department of Human Genetics. In 1957–58 samples were tested at the Department of Human Genetics of the University of Michigan by the follow-

---

[1] The financial support of the Rockefeller Foundation and the United States Atomic Energy Commission in these studies is gratefully acknowledged.

[2] National Science Foundation Postdoctoral Fellow.

[3] Contribution No. 101, Department of Natural Sciences, Michigan State University.

ing methods. All typings were performed with washed 2% suspensions of red blood cells. The routine typing fluids were obtained from commercial sources, but the methods of testing were slightly modified from the vendor's specifications so as to standarize the procedures. All tests were set up with one drop (approx. 0.05 ml) of serum and one drop of red cell suspension. Centrifuge readings were taken after spinning at 2000 rpm for approximately 5 seconds. The tests for each day included positive and negative controls for each reagent, with the exception of those reagents for which one type is exceedingly rare, e.g., Tj^a-negative control, U-negative control, Di^a-positive control (although the potency of the anti-Di^a serum was confirmed with a Di^a-positive blood kindly supplied by Dr. M. Layrisse) and C^w-positive control (although the anti-C^w serum was capable of detecting C^w bloods in a screening of Caucasians).

In order to conserve serum all bloods were typed by means of a two stage screening procedure in which the reactions in the first stage determined the tests to be performed in the second stage, as shown below.

Bloods reacting weakly with anti-A_1 (absorbed B blood) were retested in most cases with an extract of *Ulex europeous* (specific for A_2 and O) and in the other cases with both the *Ulex* extract and an extract of *Dolichos biflorus* (specific for A_1).

The original screenings for M and N were performed using commercially available rabbit immune sera. In general all the reactions for M and N were quite weak even though the control bloods reacted strongly. The difference in intensity of reaction between the African and control bloods is probably attributable to the greater age of the former. Bloods giving doubtful reactions were re-examined with two rabbit anti-M and a potent rabbit anti-N serum (these sera were made in this laboratory), and in some cases with a human anti-M.

Bloods reacting atypically with the routine Rh typing fluids were retested with several sera specific for the antigen involved, each serum being obtained from a different commercial laboratory.

The Coombs serum used in screening for Kell and Duffy was composed of a mixture of two rabbit anti-human sera. This serum mixture gave good reactions with Kell and Duffy positive controls set up daily, even though there was almost universal failure to detect evidence for Kell or Duffy sensitization among the African bloods. Unfortunately it was not feasible to attempt large scale absorption experiments to determine the true antigenic composition of these bloods.

RESULTS

The complete results by phenotype are given in tables 1–3. The results are presented separately for the specimens tested in 1955–56 at the Child Research Center and those tested in 1957–58 at the Department of Human Genetics. For the most part the results are shown by tribe. However, due to the small numbers tested in the Ivory Coast and Upper Volta and to the multiplicity of small tribes in these regions, none of the tribal samples from these regions, with the exception of the Mossi and the Kru, is greater than 20; so that we have combined the samples from these regions into larger groupings. These groupings undoubtedly contain populations which differ significantly in the frequency of some blood group genes. But it should be noted that the breeding unit in this part of West Africa is frequently even smaller than the tribe; so that many of our tribal groups also contain several breeding "isolates," which may well differ significantly in the frequency of some blood group genes.

First stage reagent	First stage reaction	Then tested with second stage reagent
A	+	Anti-A_1 (absorbed B blood)
A	−	Rabbit anti-A (titer 1/800)
Saline C	+	Anti-C^w, anti-c
Saline D	−	Incomplete anti-D by Coombs test
Saline E	+	Anti-e (negatives retested with trypsinized blood)
K	+	Anti-k

TABLE I

The ABO and MN blood groups of several West African populations

Population	Date tested	Total	O	A_1	A_2	A[1]	B	A_1B	A_2B	AB[1]	M	MN	N
Liberia													
Kpelle	55–56	179	79	38	4	9	38	5	4	2	26	99	54
	57–58	191	86	33	18		41	7	6		49	78	64
Loma	55–56	141	60	29	6	7	34	5			30	70	41
	57–58	102	43	14	7		31	6	1		25	49	28
Bassa	55–56	160	85	20	4	8	36	4	3		29	78	53
	57–58	98	46	18	5		25	3	1		26	44	28
Webbo	55–56	77	46	5	3		22	1			15	39	23
	57–58	103	59	17	4		20		3		23	51	29
Grebo	55–56	43	18	7	3	2	13				8	23	12
	57–58	54	28	11	2		13				11	27	16
Kru	55–56	86	52	15	2	3	14				23	51	12
	57–58	56	30	7	3		14	1	1		15	28	13
Krahn	55–56	54	26	12	3	3	7	2		1	5	27	22
	57–58	23	11	5	3		4				6	9	8
Gbandi	55–56	125	64	11	6	1	38	4	1		32	55	38
	57–58	24	10	7	2		3	1	1		7	12	5
Gissi	55–56	93	49	21	1	4	17	1			23	36	34
	57–58	36	16	11	2		6		1		9	17	10
Gola	55–56	117	71	15	3	2	24	1	1		24	56	37
	57–58	35	21	5	1		7	1			11	10	14
Gio	55–56	47	22	9	1	1	11	2	1		4	20	23
	57–58	52	25	7	2		16	2			8	21	23
Mano	55–58	117	56	15	3	6	32	5			22	47	48
Vai	55–58	60	35	6	3	1	13	1	1		16	33	11
Mende	55–58	54	26	7	5	2	11	2	1		13	26	15
Dei	55–58	42	28	6	1		6		1		9	21	12
Mandingo	55–58	32	16	7	1		6	1	1		11	14	7
Belle	55–58	11	5			1	5				2	4	5
Americo-Liberian	55–58	14	11	2			1				5	5	4
Other tribes	55–58	125	56	17	7		42	2	1		23	67	35
Total (Liberia)		2351	1180	377	105	50	550	57	29	3	510	1117	724
Ivory Coast													
Wobe-Guere	55–58	38	16	9	4		8	1			10	18	10
Bete-Bakwe	55–58	28	16	2	1		7	1	1		5	15	8
Kru	55–58	36	25	7	1		3				15	15	6
Lagoon	55–58	27	20	2	2		2			1	8	11	8
Agni-Baoule	55–58	19	11	3			5				3	10	6
Other tribes	55–58	71	22	18	6		20	3	2		12	42	17
Upper Volta													
Mossi	55–58	47	22	6	2		13	3	1		10	20	17
Other tribes	55–58	51	19	9	2		17	2	2		10	25	16
Dahomey													
All tribes	55–58	27	16	4	2		5				4	12	11
Total (Ivory coast, Upper Volta, and Dahomey)		344	167	60	20		80	10	6	1	77	168	99

[1] Not tested as to subgroup.

TABLE 2

The Rh blood groups of several West African populations

Tribe	Date tested[1]	ccDee	ccddee	ccD^{u}ee	CcDee	ccDEe	CcDEe	CCDee	ccDEE	CcD^{u}ee	Ccddee	ccddEe	CDee	ccDE	CDE	Cddee	ccddE	CD^{u}ee	Total
Liberia																			
Kpelle	55–56	111	4										34	23	5	1	1		179
	57–58	128	7	2	27	16	2	2	2	4		1							191
Loma	55–56	91	4										21	20	3	2			141
	57–58	81	4	2	9	4	1	1											102
Bassa	55–56	91	9										27	22	8	2	1		160
	57–58	61	4	5	11	12	1	1	1		2								98
Webbo	55–56	55	2										9	6	5				77
	57–58	55	2	5	21	10	2	2	2	2	2								103
Grebo	55–56	23	2	3									7	8					43
	57–58	31		3	8	10	1	1											54
Kru	55–56	55	6										15	8	2				86
	57–58	33		2	10	5	3				3								56
Krahn	55–56	30	2										10	9	2	1			54
	57–58	13		1	4	4	1												23
Gbandi	55–56	76	4										21	16	7	1			125
	57–58	16		1	3	3				1									24
Gissi	55–56	56	5										13	16	2	1			93
	57–58	24	1	2	2	7													36
Gola	55–56	83	3	1									19	8	2	1			117
	57–58	27	1	3	1	2		1											35
Gio	55–56	31	4										2	7	3				47
	57–58	28	4	4	9	2	1		2	2									52
Mano	55–58	76	1		3	1							23	6	5	1	1		117
Vai	55–58	41	1	3	2	1							6	5	1				60
Mende	55–58	35	3	1	1	4			1				4	5					54
Dei	55–58	32	4										3	3					42
Mandingo	55–58	19	1	1	1	3							4	2				1	32
Belle	55–58	4			1	1							3	2					11
Americo-Liberian	55–58	5	4		1					1				1	1	1			14
Other tribes	55–58	76	4	10	15	13		3	1				1	2					125
Total[2] (Liberia)	55–56	845	54	5									218	164	45	10	3	1	1345
Total[2] (Liberia)	57–58	561	24	34	113	85	12	8	8	9	7	1							862
Ivory Coast																			
Wobe-Guere	55–58	30			1	4							2						38
Bete-Bakwe	55–58	11	1	1	6	1	1						6	1					28
Kru	55–58	22			7	6	1												36
Lagoon	55–58	10	5		2	1							4	2	3				27
Agni-Baoule	55–58	8	1										4	6					19
Other tribes	55–58	51	3	2	8	6							1						71
Upper Volta																			
Mossi	55–58	21	1		5	11	2						2	3	2				47
Other tribes	55–58	31	3	2	6	5	1	1		1			1						51
Dahomey																			
All tribes	55–58	19	3	1	2				1				1						27
Total (Ivory Coast, Upper Volta, Dahomey)		203	17	7	37	34	6	1	1	1			21	12	5				344

---

[1] In 1955–56 all samples were tested with anti-C, D, and E, and 21 of the 68 D-bloods were tested for D^u. In 1957–58 all samples were tested according to the procedure outlined in the text, under Methods.

TABLE 3

The distribution of the P, U, Henshaw, Diego, Kell, Duffy, Kidd, and Jay blood groups in several West African populations

Population	P No./Neg.	U No./Neg.	Henshaw (He) No./Pos.	Diego (Di^a) No./Pos.	Kell (K) No./Pos.	Duffy (Fy^a) No./Pos.	Kidd (Jk^a) No./Neg.	Jay (Tj^a) No./Neg.
Liberia								
Kpelle	191/26	42/0	22/3	75/0	152/1	152/0	35/8	18/0
Loma	102/9	57/0	39/1	40/0	61/0	61/0	17/8	10/0
Bassa	98/19	26/0	10/0	36/0	63/0	63/0	5/1	2/0
Webbo	103/4	105/0	77/1	57/0	57/1	57/0	28/4	28/0
Grebo	54/6	55/1	40/1	27/0	29/0	29/0	11/3	11/0
Kru	56/3	60/0	29/1	43/0	45/1	45/0	14/2	14/0
Krahn	23/3	25/0	18/0	11/0	14/0	14/0	5/2	5/0
Gbandi	24/3	87/0	59/1	6/0	12/0	12/0	3/0	2/0
Gissi	36/2	42/1	37/1	14/0	14/0	14/0	1/0	—
Gio	52/10	13/0	2/0	24/0	30/0	30/0	17/8	9/0
Mano	23/4	5/0	1/0	6/0	12/0	12/0	2/1	1/0
Vai	20/3	18/1	15/0	12/0	13/0	13/0	1/0	—
Gola	35/6	60/0	56/0	25/0	27/0	27/0	—	—
Mende	27/5	9/0	9/0	6/0	11/0	11/0	—	—
Other tribes	135/17	40/0	31/1	118/0	118/0	118/0	3/3	2/0
Total (Liberia)	979/120 (12.3%)	644/3 (0.5%)	445/10 (2.2%)	503/0	661/3 (0.5%)	661/0	142/40 (28.2%)	102/0
Ivory Coast								
Wobe-Guere, Bete-Bakwe, Kru	87/13	12/1	12/1	87/0	87/0	87/7	—	—
Lagoon, Agni-Baoule	12/2	34/1	34/1	12/0	12/0	12/0	—	—
Other tribes	64/14	7/0	7/2	64/0	64/0	64/0	—	—
Upper Volta								
Mossi	35/5	12/1	12/0	35/1	35/0	35/0	—	—
Other tribes	40/8	11/0	11/0	40/0	40/0	40/0	—	—
Dahomey								
All tribes	20/5	4/0	4/0	20/0	20/0	20/0	—	—
Total (Ivory Coast, Upper Volta, Dahomey)	258/47 (18.2%)	80/3 (3.8%)	80/4 (5.0%)	258/1 (0.4%)	258/0	258/7 (2.7%)	—	—

The gene frequencies were calculated by the methods outlined in Mourant ('54). The numbers of tests performed differ for the various blood group systems, primarily because of the rarity of certain anti-sera. In addition, with respect to two blood group systems (ABO and Rh), only a portion of the samples were tested for some of the subgroups. For example, not all of the D-negative samples were tested for D^u; to obtain the frequency of the D^u gene we have applied the percentage of D-negative bloods which were found to be D^u to the total number of D-negative bloods.

The gene frequency calculations are also complicated in several cases by significant differences between the two testing periods in the frequencies of the blood group phenotypes. Aside from the fact that at times different populations were sampled, these differences are most likely due to a combination of the following three reasons: (1) condition of the blood samples on arrival at the laboratory, (2) variability in the strength of the anti-sera used, and (3) differences in the testing procedures of the two laboratories. These inconsistencies only affect some of our calculations and will be treated in greater detail in our calculations for the various blood group systems. We will begin with the ABO system.

The ABO system. A χ^2 test indicates that the frequencies of the ABO blood group genes vary significantly among the tribes of Liberia ($\chi^2 = 57.939$, 15 d.f., $P < 0.001$). There are no significant differences between the samples for the various tribes in 1955–56 and in 1957–58, and in addition the results are not significantly different from Julien's ('37) data for the Mano, Gio, Kpelle, Loma, Kru, Bassa, Mende, and Vai tribes. Thus, although there is great variability among the tribes, their frequencies appear to have been rather constant for the last 25 years. In contrast to the ABO blood group genes, the frequencies of the subgroups of A are not significantly different among the tribes when the proportion of A which is A_2 is tested by χ^2 for our 1955–56 samples ($\chi^2 = 16.234$, 15 d.f., $0.3 < P < 0.5$, or for our 1957–58 sample ($\chi^2 = 7.516$, 13 d.f., $0.75 < P < 0.90$). Hence, although the frequency of blood group A may vary considerably among the tribes, the proportion of A which is A_2 does not vary significantly. However, the relative proportion of A_2 which we found i
1957–58 is significantly greater than tha
found in 1955–56 ($\chi^2 = 7.558$, 1 d.f.
$0.005 < P < 0.010$). This difference ma
be due in part to differences in the A_1 anti
sera which were used by the two labora
tories, and in part to differences in the test
ing procedures of the two laboratories
especially with reference to the use of
Ulex preparation in one laboratory. I
1955–56 at the Child Research Cente
Laboratory all samples were tested once
but in 1957–58 at the Department of Hu
man Genetics Laboratory almost all wea
positives were retested and some were re
tested several times. In addition, for man
blood group antigens two or more anti-ser
were used at the Department of Huma
Genetics Laboratory and the weakly reac
ing samples tested simultaneously wit
them. Because of the retesting of all wea
positives, it would be expected that th
number of positives for any test woul
decrease from our 1955–56 survey to ou
1957–58 survey. Since this actually o
curred for many of the blood group sy
tems, this difference in testing procedu
seems to account for the significant di
ferences in the frequency of various ant
gens which were found by the two labor
tories. In 1955–56, 83% of the A-ty
bloods which were tested for A_1 were pos
tive, while in 1957–58, 73% were positiv
In 1955–56 the samples were tested on
with a human anti-A_1 (absorbed B blood
but in 1957–58 weak positives for
were retested with a *Ulex* extract whi
gives a strong reaction with A_2 and fa
to react with A_1. Thus, in many cas
(55%) samples which were weakly po
tive with anti-A_1 reacted strongly wi
the *Ulex* extract and hence were treat
as A_2. Because of this additional testi
it can be seen that a decrease in the f
quency of A_1 would be expected in 195
58. The ABO gene frequencies for t
tribes listed in table 1 are shown in ta
6. Since the tribes do not differ sign
cantly in the proportion of the A ge
which is A_2 we have not calculated the
and A_2 gene frequencies separately, but
can be stated on the basis of the 1957–
results that about 27% of the A genes
A_2.

The MN system. For the MN syst
there were no significant differences

tween the sample for the particular tribe in 1955–56 and that in 1957–58, and in only two tribal samples, the Kpelle in 1957–58 and the Gola in 1957–58, were the phenotypic frequencies significantly different from those expected in a Hardy-Weinberg equilibrium, due to an apparent excess of homozygotes. The Kpelle and Gola are among the largest tribes of Liberia and contain several breeding isolates. This apparent departure from Hardy-Weinberg equilibrium in the two samples may be due to the statistical phenomenon first noted by Wahlund ('28).[4]

A further possible illustration of the operation of this principle is to be observed when the total MN determinations for Liberia in 1957–58 are compared with the expected values in a Hardy-Weinberg equilibrium. Here again there is a very significant excess of homozygotes ($\chi^2 = 8.062$, 1 d.f., $0.001 < P < 0.005$), and for the total of both 1955–56 and 1957–58 there is also an excess of homozygotes which is significant ($\chi^2 = 5.037$, 1 d.f., $0.010 < P < 0.025$). Since the tribes of Liberia differ significantly in their M gene frequencies ($\chi^2 = 33.759$, 15 d.f., $0.001 < P < 0.005$), as in the Kpelle and Gola example cited earlier, these apparent excesses of homozygotes appear to be due to Wahlund's principle. If the expected values of the three phenotypes are adjusted according to Wahlund's formula, then the observed values are not significantly different from the expected ($\chi^2 = 2.935$, 1 d.f., $0.05 < P < 0.10$). When it is remembered that the tribal frequencies are most likely means of several isolates and hence that the variance of the M gene frequency among the tribes of Liberia is most likely less than its variance among the breeding isolates of Liberia, then the data seem to be an even better fit to this formula, since we have corrected the zygotic proportions by the lesser value, the variance of the M gene among the tribes.

In this connection it should be noted that a deficiency of heterozygotes for MN has been a rather common finding in Africa. Moullec, Linhard, and Sutton ('52) reported a deficiency of heterozygotes for MN from the tribes centered around Dakar, and proposed a silent M_2 gene in appreciable frequencies as an explanation. Shapiro and Vandepitte ('55) have also reported a deficiency of MN heterozygotes from the Congo. Thus, it appears that surveys in Africa which combine many tribes, which in turn contain many isolates, are very likely to find a deficiency of MN heterozygotes, depending, of course, on the variability of the M gene among the isolates sampled. Since many tribes in Africa contain more than one breeding isolate, this could also happen on surveys which recorded their results by tribe. The fact that this occurs frequently in Africa and not in Europe is due to the greater variability between isolates in Africa, which is a result of the smaller size of the isolates and the more limited gene flow between them.

The Rh system. In contrast to the ABO and MN systems, the Rh phenotypic frequencies do not vary significantly among the tribes of Liberia ($\chi^2 = 76.857$, 60 d.f., $0.05 < P < 0.10$). For this test we have combined our data for 16 tribes into the phenotypes, cDe, CDe, cDE, CDE, and all D-negative (including D^u), irrespective of C and E reactions. Although the tribes do not differ significantly, we have calculated the chromosome frequencies separately for each tribe, and these together with the chromosome frequencies of the tribes of the Ivory Coast and Upper Volta are shown in table 6. For the calculation of the tribal frequencies, we have combined the data

---

[4] If a population is subdivided into K breeding isolates of approximately equal size, then where q_1 is the frequency of the M gene in the ith breeding isolate and $\overline{q}$ is the frequency of the M gene for the total population, the following relations hold:

$$\overline{q} = \frac{\Sigma q_i}{K} \qquad \sigma q^2 = \frac{\Sigma(q_i - \overline{q})^2}{K} = \frac{\Sigma q_i^2}{K} - \overline{q}^2$$

And if each breeding isolate is large enough so that the zygotic proportions will be:

$$q_i^2;\ 2q_i(1 - q_i);\ (1 - q)^2$$

Then the zygotic proportions for the total population will be:

$$\text{MM: } \frac{\Sigma q_i^2}{K} = \overline{q}^2 + \sigma q^2$$

$$\text{MN: } \frac{2\Sigma q_i(1 - q_i)}{K} = 2\overline{q}(1 - \overline{q}) - 2\sigma q^2$$

$$\text{NN: } \frac{\Sigma(1 - q_i)^2}{K} = (1 - \overline{q})^2 + \sigma q^2$$

Thus it can be seen that for the total population there will be an increase in homozygotes which will be proportional to the variability of the gene frequency among the subdivisions.

for 1955–56 and that for 1957–58, but it should be noted that the phenotype frequencies of the total sample for 1955–56 differ significantly from those of the 1957–58 sample. In the 1955–56 sample there is a significant excess of the CDE phenotype and smaller excesses of the CDe and cDE phenotoypes. As for the A_1 antigen of the ABO system, these excesses of positives for the C and E antigens seem to be due to differences in the testing procedures of the two laboratories. There were many weak positives for these antigens and these were retested in 1957–58. As a result many were found to be negative. Since the phenotypic frequencies found in 1955–56 are significantly different from those found in 1957–58, we have calculated the chromosome frequencies separately for the two sets of data, and the results are shown in table 4. In 1955–56 most of the D-negative bloods were not tested for D^u, so that the relative proportion of D-negative bloods which are positive for D^u is based on a very small sample. Aside from this difference it can be seen that the two samples from Liberia agree quite closely. All the C-positive samples in 1957–58 were tested for C^w; no positives were found in the survey. This antigen is known to be rare in Africa, but this finding of 0% is the lowest to be reported (summary in Mourant, '54).

The Fy^a system. Only 7 Fy^a-positives were found in the entire survey, and these were all in one shipment. Since this shipment arrived at the laboratory in a poorer condition than most shipments and was tested much later than most, we would suspect these to be false positives, inasmuch as 200 clotted blood samples in especially good condition, and several hundred oxalated samples from neighboring and related tribes in Liberia were all negative. A low frequency of the Fy^a gene is characteristic of African populations, but this finding of essentially zero seems to be confined to West Africa, where Race and Sanger ('58) have also reported 0% among a small sample (37) of Nigerians and Ghanaians. Shapiro and Vandepitte ('55) report 8% positives for the Fy^a antigen in the Congo, and Zoutendyk ('55) reports 28% among the Hottentots and 16% among the Bushmen in South Africa. Gershowitz (unpublished) has observed 3.8% Fy^a-positives among 157 natives of Kenya. There is thus the suggestion of a lower frequency of Fy^a-positives in West than in East or South Africa, but no evidence at present for a cline *within* West Africa. There is some disagreement as t the frequency of Fy^a-positives among the American Negro since Miller et al. ('51 report 26% positives among a sample o 200 New York Negroes, while Sanger Race, and Jack ('55) report 10.4% for a sample of 125 of the same population. In this laboratory, 20.3% of a sample of 20 American Negroes were Fy^a-positive (Ger showitz, unpublished). In any case, how ever, a very low frequency would b expected among Africans in view of th 65% Fy^a-positives among Caucasians an the fact that the American Negro gen pool appears to have about 25% Caucasia genes (Glass, '55).

TABLE 4

The Rh chromosome frequencies of the 1955–56 and 1957–58 shipments from Liberia (excluding the Belle, Americo-Liberians and tribes listed under Other)

	1955–1956	1957–1958
Number tested	1,345	862
cDe	0.6039	0.5853
CDe	0.0882	0.0688
cDE	0.0765	0.0637
cde	0.1810	0.1661
Cde	0.0189	0.0223
cdE	0.0053	0.0024
cD^ue	0.0263	0.0921

The Tj^a and Di^a systems. No Tj^a-nega tives were found on the survey, but in vie of the rarity of the Tj^b gene and the size o our sample, none would be expected. Th results for the Diego system have been dis cussed in another publication (Gershowit '59).

The K, U, and He systems. Our result for the Kell, U and Henshaw systems ar similar to those of other investigations i Africa. No Kell positives were found in th Ivory Coast specimens and the frequen of Kell positives was very low in Liberi (0.5%). The frequency of U-negative was also quite low in Liberia (0.5%), bu this frequency rose to 3.8% in the Ivo Coast. A similar cline in the frequency o the Henshaw antigen also seems to b present with 0.5% Henshaw positive i Liberia, 5.0% positive in the Ivory Coas and 4.3% in Ghana to the east of the Ivo

TABLE 5

The frequencies of the P and Jk^a blood groups in the shipments from Liberia, in relation to time of shipment

Date and method of shipment	P blood group			Jk^a blood group		
	No. tested	No. neg.	Freq. neg.	No. tested	No. neg.	Freq. neg.
Oct. 57 (Oxalated blood)	79	11	0.139			
Oct. 57 (Oxalated blood)	138	2	0.015	60	12	0.200
Nov. 57 (Oxalated blood)	42	1	0.024	42	24	0.571
Jan. 58 (Oxalated blood)	40	1	0.025	40	4	0.100
Feb. 58 (Clotted blood)	218	24	0.110			
May 58 (Oxalated blood)	158	41	0.260			
Jun. 58 (Oxalated blood)	76	16	0.211			
Jun. 58 (Oxalated blood)	150	22	0.147			
Jun. 58 (Oxalated blood)	82	8	0.098			
Aug. 58 (Oxalated blood)	54	5	0.093			
Aug. 58 (Oxalated blood)	73	9	0.123			
Totals[1]	1,110	140	0.126	142	40	0.282

[1] The total for the P blood group does not agree with that on table 3 because the results for several regnant women and individuals known to be related are included here but not on table 3.

oast (Mourant, '54). While in Ghana nd Nigeria the Henshaw gene seems to e associated only with N (Mourant, '54), e have found Henshaw positives associated with M as well as N, as has Nijenuis ('55) in the Congo and Pollitzer ('58) n the United States. Our positive Henshaw eactions were strong (++++) and associated with the MN blood groups as ollows:

	MM	MN	NN
Henshaw positives	3	6	5

The P and Jk^a systems. The P and Jk^a lood group antigens have more intermediate frequencies among the tribes of iberia than the other less well-known lood groups, and, as perhaps would be xpected from the greater sampling variance at intermediate frequencies, the tribal requencies seem to show greater variability. However, this increased variability or these blood groups may be due in part o other factors. For both blood groups here is a greater variability in the frequency of positives in the different shipments than was observed for the other roups, raising the possibility of technical ifficulties. The frequencies of the P and Jk^a antigens in each shipment for which hey were tested are shown in table 5. For he P blood group the variability among the hipments in the frequency of P-negatives eems to be due in part to variability in the trength of the reagent, and at one time during our survey (May, 1958) the reagent became noticeably so much weaker that it was discarded. Nonetheless, all the variability in the frequency of P-negatives is not due to differences in the strength of the reagent. With a new reagent in June, 1958, 21% negatives was found which compares to the 26% negatives found in May with the weaker reagent. On the other hand, for the Jk^a blood group the same reagent was used for all tests, and the differences in the frequency of Jk^a-negatives among the shipments do not seem to be attributable at all to a weakening of the anti-sera used. Most of our Jk^a reactions were rather weak, and our data indicate that this antigen may be more subject to deterioration. However, the shipment with a high proportion of Jk^a-negatives (25 Nov., 1957) did not appear to be in any worse condition than the others, nor was it tested any later after collection.

If we take the observed frequencies of the P and Jk^a antigens at face value, ignoring the possibility of technical error, our results differ from what has usually been reported on African and African-derived populations. In previous studies on West Africans from Nigeria and Ghana and American Negroes, the frequency of individuals negative for Jk^a has been less than 7% (summary in Mourant, '54). Our finding of 28% Jk^a-negatives is thus much higher than those of other studies. With respect to the P system, 13.5% of the 1237 natives we tested in this respect were P-negative. Limited studies on the natives of Nigeria and Ghana, as well as American Negroes, have shown values of less than 7% P-negatives (summary in Mourant, '54), but Moullec et al. ('52) found a 12% value in 781 natives from tribes in the vicinity of Dakar. In addition, Shapiro ('51, '53) found 13.2 and 8.0% P-negatives in two studies of South African Bantu, and Goldsmith (quoted in Mourant, '54) found 27.9% P-negatives in the Somali, although the Somali are a Cushitic tribe in Ethiopia and Somaliland and thus not strictly "Negro." In any case it may well be that there is considerable variability in the frequency of these blood groups in different parts of Africa, which as for many other blood groups limits the usefulness of the term "African" or "Negro" in reference to the frequencies of these blood groups. For the Jk^a group, then, our limited results suggest a higher frequency of negative reactors in the tribes of Liberia and the Ivory Coast than in the tribes of surrounding regions, but the results are insufficient to establish the occurrence of a cline if such exists. With respect to the P antigen the differences from the values reported for surrounding regions are less striking, and, in view of the possible technical problems mentioned above, are not thought worthy of further discussion.

DISCUSSIONS

Before we attempt to discuss the anthropological and genetic significance of our findings, we would like to point out certain implications of the significant differences in our survey which have been associated with different testing procedures. We think the possibility that such differences may occur, or in other words that there is a degree of uncertainty in blood typing which must be borne in mind in the interpretation of blood group gene frequencies, especially when "old" blood is used, has not been properly emphasized in most publications. Our findings would seem to imply that in a program in which blood specimens which are *one week or more old* are subjected to a single test for a particular antigen, a significant number of specimens will exhibit weak positive reactions which are not duplicated on a retest. The differences in the two laboratories which were noted in this study stem almost entirely from the availability, in one laboratory,
personnel for retesting procedures.
should also be noted that many of t
"significant" differences are actually rel
tively small, and emerge as significant on
because of the size of the samples co
cerned. It may be that oxalation of o
samples was responsible for these fal
positives, which would limit the implic
tions of our findings. In this connection
should be noted that Osborne ('58) h
presented evidence that differences
technique between laboratories may be
significant factor in the percentage of po
tive reactions even when fresh, clott
blood is used. It is impossible to estima
to what extent routine blood grouping tec
niques, which are quite universally e
ployed in survey studies, have led to ove
estimates of antigen frequencies in oth
investigations. Be that as it may, in th
present instance we have combined th
results of the two series, although reco
nizing that in consequence the antigen an
gene frequencies resulting thereby may f
some systems be slightly higher than th
true values.

In any case the results of our survey a
cord in many general features with th
usual findings for the major blood grou
systems in West Africa and in other par
of the world. For West Africa our resul
are similar to the findings in those regio
thus far studied, namely Ghana an
Nigeria (summary in Mourant, '54), Po
tuguese Guinea (Mourant, '58; Trinca
Franco, Gouveia and Parreira, '53), an
the Senegal (Moullec, Linhard and Sutto
'52). Each of these studies shows th
there is significant variability in the AB
and MN systems within the respecti
countries, but there do not appear to
significant clines in the frequencies
these genes. Among the tribes of Liber
there are some who possess frequenci
similar to some tribes in Ghana, othe
who are similar to tribes in Portugue
Guinea, and still others similar to tribes
the Senegal; and these similarities
not appear to be related to linguisti
ethnic, or cultural similarities. Thus, th
variability in the ABO, MN, and Rh sy
tems appears to be for the most part ra
dom. On the other hand, although data
the U, K, He, P and Jk^a systems are le
extensive, there may well be in We

frica, centering in the vicinity of Liberia, ignificant clines in the frequency of some f the responsible genes, namely, He and J, and —somewhat more indefinite—Jk^a.

Because of the presence in Liberia and he Ivory Coast of a significant cline in the requency of the sickle cell gene, a gene vith a marked selective advantage in the eterozygous state (Raper, ’56; Vandepitte nd DeLaisse, ’57; Lambotte-Legrand, ’58), ur data present an unusual opportunity o compare this cline with the frequencies f the blood group genes. We will restrict he detailed comparison to the ABO, Rh, nd MN systems—the major systems—for vhich we have the more complete data. n table 6 we have arranged the tribes by inguistic affiliation and, as well as possible, in descending frequency of the sickle ell gene. In table 6 the sickle cell gene an be seen to have a very significant cline mong the tribes of Liberia, while none of he other blood group systems shows a similar cline. When the tribes are grouped by inguistic affiliation, which is used in table 6 to indicate ethnic relation, there does not seem to be any striking overall association between the frequencies of the blood group genes and linguistic affiliation. To be sure, closely related tribes such as the Mano and Gio do show marked similarities in the frequency of some blood group genes; and the Mandingo and Vai, whose languages are closely related, do have in common a much higher frequency of the M gene than is usual in Liberia. However, there seem to be as many differences between closely related tribes as there are similarities. Thus, the variability in these blood group systems seems to be for the most part random when examined in this manner. One of us (Livingstone, ’58a) has postulated that the distribution of the sickle cell gene in Liberia is due to the recent advance of the gene by a relatively small amount of gene flow between stable populations followed by a rapid increase in gene frequency due to intense selective pressures. The absence of parallel clines in the major blood group systems seems to imply that these other genes were already present in near equilibrium frequencies prior to this gene flow.

There is also a rather striking cline in the frequency of the sickle cell gene in Portuguese Guinea, where the West Atlantic-speaking tribes on the seacoast between the Cacheu and Casamance Rivers have very low frequencies of the sickle cell gene with the frequency of this gene increasing as one proceeds inland from this stretch of coastline. As is the case in Liberia, the tribes with very low frequencies of the sickle cell gene in Portuguese Guinea seem to be relict populations of the primitive inhabitants of West Africa who were forced back into this area by later migrations. In table 7 are shown the available data on the frequencies of the sickle cell gene and the ABO and Rh blood group genes in the tribes of Portuguese Guinea the tribes being arranged in ascending frequencies of the sickle cell gene. As in Liberia there seems to be little or no association between the frequencies of the sickle cell gene and those of the blood group genes. Thus, once again the conclusion seems to be that the variability in the frequency of the blood group genes is not associated with the cline in the sickle cell gene or with common ancestry.

A third study of this nature, that by Hiernaux (’56) of the populations of Ruanda-Urundi and the eastern Belgian Congo, involving the ABO, MN, Rh, and sickling systems, also seems to point in general to a similar conclusion, although there is one exception to be discussed below. In table 8 the populations of Hiernaux’s study are arranged in a similar manner to the ordering of the populations of Liberia in table 6, but we have added the mean altitude of the tribe’s habitat in table 8, since this factor seems to affect the distribution of the sickle cell gene very strikingly. The correlation between altitude and the frequency of the sickle cell gene ($r = 0.73$) is significant at the 1% level. It can be seen that all tribes which are above 1500 meters in altitude have very low frequencies of the sickle cell gene, which is presumably related to the fact that there is little falciparum malaria at these heights. However, the tribes who inhabit the lower altitudes do not invariably have high frequencies of the sickle cell gene. Thus, other factors, in addition to selection with respect to falciparum malaria, seem to be involved in determining the distribution of the sickle cell gene in this part of Africa, as is the case in West Africa (Livingstone, ’58b). In Ruanda-

TABLE 6

A comparison of the cline in the sickle cell gene with the frequencies of various blood group genes

Tribe	Language	Sickle cell gene			ABO blood groups						MN blood groups		
		Freq.	Means		p(A)	q(B)	Means				p(M)	Means	
Liberia													
Gissi	West Atlantic	0.108	0.083	0.078	0.185	0.115	0.144	0.118	0.146	0.135	0.454	0.451	0.492
Gola	West Atlantic	0.058			0.103	0.121					0.447		
Mandingo	Mande-tan	0.092	0.084		0.161	0.125	0.132	0.128			0.563	0.553	
Vai	Mande-tan	0.075			0.103	0.131					0.542		
Mende	S.W. Mande-fu	0.082	0.072		0.168	0.135	0.161	0.158			0.482	0.471	
Gbandi	S.W. Mande-fu	0.074			0.119	0.174					0.487		
Loma	S.W. Mande-fu	0.065			0.174	0.179					0.471		
Kpelle	S.W. Mande-fu	0.065			0.183	0.145					0.442		
Bassa	Kru	0.041	0.030	0.019	0.137	0.150	0.117	0.118	0.126	0.147	0.450	0.457	0.411
Dei	Kru	0.019			0.097	0.086					0.463		
Mano	N.E. Mande-fu	0.009	0.009		0.135	0.175	0.135	0.176			0.399	0.364	
Gio	N.E. Mande-fu	0.009			0.134	0.176					0.328		
Kru	Kru	0.003	0.003	0.003	0.128	0.062	0.169	0.079	0.151	0.118	0.546	0.462	0.460
Krahn	Kru	0.003			0.211	0.096					0.377		
Grebo	Kru	0.004	0.004		0.167	0.173	0.133	0.157			0.454	0.458	
Webbo	Kru	0.003			0.099	0.140					0.461		
Ivory Coast													
Kru	Kru	0.000	0.006	0.025	0.123	0.048	0.140	0.098	0.151	0.121	0.625	0.551	0.509
Wobe-Guere Bete-Bakwe	Kru	0.011			0.156	0.148					0.477		
Lagoon, Agni-Baoule	Kwa	0.031	0.043		0.091	0.091	0.162	0.144			0.467	0.466	
Other tribes	Misc.	0.054			0.233	0.197					0.465		
Upper Volta													
Mossi	Gur	0.042	0.052	0.062	0.114	0.179	0.136	0.205	0.135	0.159	0.426	0.434	0.451
Other tribes	Misc.	0.061			0.157	0.230					0.441		
Dahomey													
All tribes	Gur-Kwa	0.071			0.133	0.112					0.468		

Tribe	Language	Rh blood groups											
		cDe	CDe	cDE	All D^u + d	Means							
Liberia													
Gissi	West Atlantic	0.576	0.058	0.102	0.264	0.613	0.063	0.071	0.253	0.599	0.064	0.083	0.254
Gola	West Atlantic	0.649	0.068	0.040	0.242								
Mandingo	Mande-tan	0.527	0.039	0.138	0.293	0.566	0.059	0.099	0.275				
Vai	Mande-tan	0.605	0.078	0.060	0.257								
Mende	S.W. Mande-fu	0.581	0.048	0.098	0.274	0.619	0.069	0.079	0.235				
Gbandi	S.W. Mande-fu	0.612	0.083	0.091	0.214								
Loma	S.W. Mande-fu	0.645	0.070	0.069	0.234								
Kpelle	S.W. Mande-fu	0.636	0.074	0.056	0.216								
Bassa	Kru	0.538	0.079	0.084	0.300	0.578	0.058	0.060	0.305	0.585	0.072	0.055	0.286
Dei	Kru	0.618	0.036	0.036	0.309								
Mano	N.E. Mande-fu	0.706	0.108	0.022	0.164	0.591	0.085	0.050	0.267				
Gio	N.E. Mande-fu	0.476	0.061	0.078	0.370								
Kru	Kru	0.577	0.082	0.065	0.275	0.574	0.088	0.088	0.251	0.562	0.087	0.088	0.265
Krahn	Kru	0.571	0.094	0.110	0.226								
Grebo	Kru	0.515	0.092	0.104	0.289	0.549	0.085	0.088	0.278				
Webbo	Kru	0.583	0.078	0.072	0.267								
Ivory Coast													
Kru	Kru	0.782	0.118	0.102	—	0.693	0.124	0.079	0.107	0.542	0.116	0.085	0.209
Wobe-Guere Bete-Bakwe	Kru	0.603	0.130	0.055	0.213								
Lagoon, Agni-Baoule	Kwa	0.354	0.153	0.139	0.354	0.491	0.108	0.091	0.311				
Other tribes	Misc.	0.627	0.063	0.042	0.267								
Upper Volta													
Mossi	Gur	0.523	0.125	0.212	0.142	0.521	0.117	0.136	0.193	0.546	0.072	0.078	0.290
Other tribes	Misc.	0.519	0.108	0.059	0.243								
Dahomey													
All tribes	Gur-Kwa	0.570	0.026	0.019	0.386								

TABLE 7

A comparison of the blood groups and sickle cell gene frequencies among the tribes of Portuguese Guinea[1]
(Numbers in parentheses refer to number of individuals tested)

Tribe	Sickle cell gene	Blood group A	Blood group B	Rh– (%)	Language
Baiote	0.001 (342)			0.252 (126)	West Atlantic
Mancanhas	0.001 (534)	0.190	0.201 (56)	0.280 (459)	West Atlantic
Bijago	0.003 (632)	0.185	0.150 (225)	0.241 (258)	West Atlantic
Balante	0.005 (776)	0.238	0.162 (58)	0.254 (481)	West Atlantic
Papel	0.007 (1244)	0.170	0.116 (87)	0.288 (410)	West Atlantic
Manjacos	0.010 (758)	0.172	0.124 (87)	0.294 (427)	West Atlantic
Felupe	0.028 (641)	0.101	0.177 (200)	0.234 (510)	West Atlantic
Nalu	0.030 (100)	0.112	0.183 (200)	0.257 (560)	West Atlantic
Biafada	0.064 (797)	0.144	0.137 (237)	0.221 (470)	West Atlantic
Pajadinca (Conagui)	0.080 (300)	0.147	0.207 (203)		West Atlantic
Fula Forros	0.079 (2053)	0.167	0.157 (327)	0.248 (408)	Fulani (W. Atl.
Fula Futa	0.087 (682)	0.172	0.139 (200)	0.295 (426)	Fulani (W. Atl.
Fula Pretos	0.126 (430)			0.279 (565)	Fulani (W. Atl.
Mandingo	0.058 (895)	0.195	0.208 (94)	0.206 (608)	Mande
Mandingo	0.075 (500)				

[1] Data from Leite and Re, '55; Trincao, n.d.; Mourant et al., '58; and Trincao et al., '53.

Urundi and the Belgian Congo there are relatively few populations which seem not to be in or approaching equilibrium for the sickle cell gene, and the major cline in the frequency of this gene seems to be determined by differences in the amount of falciparum malaria which are dependent on altitude. Thus, this appears to be a stable cline in contrast to the cline in Liberia which is not associated with differences in the endemicity of falciparum malaria.

As in Portuguese Guinea and Liberia, the distributions of Rh and MN blood group genes in Ruanda-Urundi and the eastern Belgian Congo do not show any associations with the cline in the sickle cell gene. As in Liberia there are some differences, such as the low frequency of B or the high frequency of M among the Tutsi, which seem to reflect ethnic differences, but there is certainly no overall pattern of differences in blood group gene frequencies associated with linguistic or ethnic differences. However, within the Bantu tribes the variability in the O gene is positively correlated with that in the sickle cell gene (r = + .75, 11 d.f., P < 0.01), while the A gene is negatively correlated with the sickle cell gene (r = – .72, 11 d.f., P < 0.01). It may be that the differences in altitude which have resulted in differences in selection at the sickle cel locus have also influenced the ABO genes Or it may be that malaria is a selective factor for the ABO genes and only in Ruanda-Urundi where the sickle cell cline is stable could this correlation be detected

Despite the fact that no significant clines were observed in West Africa fo the major blood group genes, in contras to the findings for the sickle cell gene, i should not be lost sight of that the tribes of West Africa differ significantly in the frequency of some blood group genes These differences seem to be the result o genetic drift or of selective response t local, unidentified factors and not associ ated with common ancestry, way of life, o region which the tribe inhabits. Since there is increasing evidence that the gene frequencies of many blood group systems are maintained by a balanced polymor phism, the similarity of blood group fre quencies throughout Africa implies tha the selective forces maintaining these balanced polymorphisms are relatively con stant throughout this region. Whatever these forces are, it is noteworthy that the great changes which resulted from the adoption of an agricultural economy by hunting populations and which are responsible for the spread of falciparum malaria and the sickle cell gene have ot affected them. In addition to the imitive "relict" populations in Portuiese Guinea and Liberia the Pygmies and shmen have frequencies of the blood oup genes which are similar to those of e surrounding Bantus. Since the transion to an agricultural economy results in anges in the diseases prevalent among e population (Hare, '55), the absence of arked differences in the frequencies of e blood group genes between agricultural d hunting populations in Africa seems imply that these diseases are not inlved in the selective forces maintaining e blood group gene frequencies. However, since it seems most likely that a great any diseases are involved in these selecve forces, an alternative explanation is at the equilibrium frequencies are the me in both a primitive hunting populaon and in an agricultural population but e maintained by quite different kinds of lection.

We turn now to consider briefly evidence r clines in the "minor" blood groups and e haptoglobin system. Evidence for the istence of a cline in the haptoglobin ne similar to that for the sickle cell gene s already been reported (Sutton et al., 9). Since intermediate frequencies of e haptoglobin alleles are found in many pulations, these frequencies appear to be aintained by a balanced polymorphism. ence the great changes in the disease enronment which are associated with the crease in the frequency of the sickle cell ne also seem to be associated with an crease in the frequency of the Hp^1 allele. nce the haptoglobin associated with this lele seems to be more efficient in binding moglobin and thus in preventing loss of moglobin via the renal system, and since hemolytic anemia is a common finding malaria because of the destruction of e red cells by the parasite, malaria could so be an important selective factor in creasing the frequency of this allele. ere is no evidence for non-uniform disibution of the Fy^a, K, P, and Tj^a or Di^a tigens in the regions covered by these udies. With respect to the possible cline the genes responsible for the He and U tigens noted above, the data are not clear as to how well these clines correlate with the sickle cell cline—further data on this point are to be desired. Finally, we record an apparent high for Jk^a negatives in the regions studied, but no evidence for a cline.

One further aspect of our findings which finds confirmation in a number of other studies is the difference in variability of the major blood group systems. It is usual to find the variability much greater among the ABO blood groups than the Rh blood groups, and the variability in the MN system is usually intermediate. This increased variability in the ABO system is usually associated with the A gene (Ruffié, '58; Mourant, '59; Hiernaux, '55). Since among a set of populations the role of gene drift and gene flow in determining gene frequencies would be the same for all genetic systems—assuming a similar antiquity for the systems involved—this increased variability seems to be due to differences in the selective forces which are operating on the different blood group systems. Whether this implies that there is stronger selection for the ABO system as Mourant ('59) has conjectured, or whether it implies that the ABO system is more subject to gene drift and hence that selective pressures are less, has yet to be determined. In any case, the unravelling of the factors which can influence gene frequencies and which are responsible for these differences in the variability of the blood group systems is one of the major problems facing human population genetics and physical anthropology today.

SUMMARY

Data are presented on the distribution of the ABO, MN, Rh, Fy^a, K, U, P, Jk^a, Tj^a, He, and Di^a blood groups in Liberia, the Ivory Coast, and Upper Volta. An attempt was made to determine whether there were clines in the frequency of the genes responsible for these groups comparable to the clines in the frequency of the sickle cell gene already demonstrated in this region. Such clines appear to be absent, with the possible exception of the He and U blood groups, and—at an even lower level of probability—the Jk^a group. The significance of these findings is discussed.

TABLE 8

The frequencies of the blood group and sickle cell genes in several tribes of Ruanda-Urundi and the Eastern Belgian Congo[1]

Tribe	Language	Altitude	Sickle cell gene		ABO blood groups				MN blood groups	
			Freq.	Mean	p(A)	q(B)	Means		p(M)	Mean
Twa-Pygmoids	Rwanda (Bantu[1])[2]	1900	0.014							
Tutsi-Ruanda	Rwanda (Bantu[1])[2]	1700	0.007							
Tutsi-Ruanda	Rundi (Bantu[1])	1800	0.008		0.130	0.061			0.606	
Hutu-Ruanda	Rwanda (Bantu[1])	1800	0.026	0.054			0.207	0.120		
Hutu-Urundi	Rundi (Bantu[1])	1700	0.060		0.166	0.129			0.513	0.497
Shi	Bantu[1]	1700	0.021		0.189	0.132			0.523	
Havu	Bantu[1]	1600	0.025		0.203	0.115			0.477	
Hunde	Bantu[1]	1500	0.022		0.222	0.111			0.485	
Swaga	Bantu[1]	1700	0.038		0.244	0.108			0.483	
Shu	Bantu[1]	1800	0.045		0.211	0.100			0.452	
Tembo	Bantu[1]	1000	0.027		0.233	0.123			0.528	
Imbo	Rwanda (Bantu[1])	1000	0.110							
Mosso	Rwanda (Bantu[1])	1000	0.130							
Fulero	Bantu[1]	1400	0.092		0.185	0.145			0.518	
Nyanga	Bantu[2]	1000	0.037		0.195	0.112			0.465	
Rega	Bantu[3]	900	0.113		0.144	0.123			0.480	
Humu	Bantu[4]	900	0.181		0.167	0.095			0.518	
Mbuba	Central Sudanic	1000	0.180		0.155	0.122			0.525	

Tribe	Language	Altitude	Rh blood groups							
			cDe	CDe	cDE	cde	Means			
Twa-Pygmoids	Rwanda (Bantu[1])[2]	1900								
Tutsi-Ruanda	Rwanda (Bantu[1])[2]	1700								
Tutsi-Ruanda	Rundi (Bantu[1])	1800	0.632	0.077	0.057	0.217				
Hutu-Ruanda	Rwanda (Bantu[1])	1800								
Hutu-Urundi	Rundi(Bantu[1])	1700	0.677	0.057	0.056	0.192	0.679	0.068	0.079	0.169
Shi	Bantu[1]	1700	0.682	0.064	0.097	0.157				
Havu	Bantu[1]	1600								
Hunde	Bantu[1]	1500	0.701	0.057	0.080	0.163				
Swaga	Bantu[1]	1700	0.654	0.092	0.082	0.163				
Shu	Bantu[1]	1800								
Tembo	Bantu[1]	1000								
Imbo	Rwanda (Bantu[1])	1000								
Mosso	Rwanda (Bantu[1])	1000								
Fulero	Bantu[1]	1400								
Nyanga	Bantu[2]	1000								
Rega	Bantu[3]	900	0.700	0.025	0.085	0.152				
Humu	Bantu[4]	900								
Mbuba	Eastern-Adamawa	1000								

[1] For all these gene frequency estimates the tribal samples number more than 125; all data from Hiernaux, '52 and '56.

[2] The Bantu languages of this region appear to consist of 4 groups of dialects, which we have indicated with superscripts.

LITERATURE CITED

Gershowitz, H. 1959 The Diego factor among Asiatic Indians, Apaches, and West African Negroes; blood types of Asiatic Indians and Apaches. Am. J. Phys. Anthrop., *17:* 195–199.

Glass, H. B. 1955 On the unlikelihood of significant admixture of genes from the North American Indians in the present composition of the Negroes of the United States. Am. J. Human Genet., *7:* 368–385.

Glass, H. B., and C. C. Li 1953 The dynamics of racial intermixture—an analysis based on the American Negro. Ibid., *5:* 1–20.

Hare, R. 1955 Pomp and Pestilence. Philosophical Library, New York.

Hiernaux, J. 1952 La gènetique de la Sicklémie et l'interet anthropologique de sa frequence en Afrique noire. Ann. Musée Royal Congo Belge, Tervuren, vol. 2.

——— 1955 Physical anthropology and the frequency of genes with a selective value: the sickle cell gene. Am. J. Phys. Anthrop., *13:* 455–472.

——— 1956 Analyse de la variation des caractères physiques humains en une région de l'Afrique centrale: Ruanda-Urundi et Kivu. Ann. Musée Royal Congo Belge, Tervuren, vol. 3.

Julien, P. 1937 Die blutgruppenverteilung bei einigen Volkern von Liberia und Sierra Leone, Westafrika (mit 7 Abbildungen). Ztschr. Rassenphysiol., *9:* 146–159.

Lambotte-Legrand, J. et C. 1958 Notes complémentaires sur la drepanocytose I. Sicklémie et malaria. Ann. Soc. Belge Med. Trop., *38:* 45–54.

Leite, A. S., and L. Re 1955 Contribution a l'étude ethnologique des populations africaines. Arch. Inst. Pasteur d'Algerie, *33:* 344–349.

Livingstone, F. B. 1958a The distribution of the sickle cell gene in Liberia. Am. J. Human Genet., *10:* 33–41.

——— 1958b Anthropological implications of sickle cell gene distribution in West Africa. Am. Anthrop., *60:* 533–562.

Miller, E. B., R. E. Rosenfield and P. Vogel 1951 On the incidence of some of the new blood agglutinogens in Chinese and Negroes. Am. J. Phys. Anthrop., *9:* 115–126.

Moullec, J., J. Linhard and E. Sutton 1952 Quelques données sur les groupes sanguins des populations d'Afrique Occidentale Francaise. Rev. Hematologie, *7:* 513–518.

Mourant, A. E. 1954 The Distribution of the Human Blood Groups. C. C Thomas, Springfield.

——— 1959 Blood groups and anthropology. Brit. Med. Bull., *15:* 140–144.

Mourant, A. E., A. C. Kopec and K. Domaniewsk
Sobczak 1958 The ABO Blood Groups. Black
well Sci. Pub., Oxford.

Nijenhuis, L. E. 1955 The Henshaw bloo
group (He) in Papuans and Congo Negroe
Vox Sanguinis, *3:* 112–114.

Osborne, R. H. 1958 Serology in physical a
thropology: technical problems as revealed b
repeated blood determinations in twins. An
J. Phys. Anthrop., *16:* 187–196.

Pollitzer, W. S. 1958 The Negroes of Charle
ton (S. C.); a study of hemoglobin types, sero
ogy and morphology. Ibid., *16:* 241–264.

Race, R. R., and R. Sanger Blood Groups i
Man. Blackwell Sci. Pub., Oxford.

Raper, A. B. 1956 Sickling in relation to mo
bidity from malaria and other diseases. Bri
Med. J., *1:* 965–966.

Ruffie, J. 1958 Étude sero-anthropologiques de
populations autochtones du versant nord de
Pyrenees. Bull. Mem. Soc. Anth. Paris, *19*
3–91.

Sanger, R., R. R. Race and J. Jack 1955 Th
Duffy blood groups of New York Negroes: th
phenotype Fy (a–b–). Brit. J. Haematol.,
370–374.

Shapiro, M., and J. M. Vandepitte 1955 Blo
groups and sickle cell trait in Congo Bant
Reports and Communications of the Vth Inte
national Congress of Blood Transfusion, p
243–246.

Sutton, H. E., J. V. Neel, F. B. Livingstone, C
Binson, P. Kunstader and L. E. Trombley 195
The frequencies of haptoglobin types in fiv
populations. Ann. Human Genet., *23:* 175–18

Trincao, C. 1958 Results of a paper electr
phoresis survey of the tribes of Portugue
Guinea. Presented at Sixth International Co
gress of Tropical Medicine and Malaria. Lisbo

Trincao, C., A. Franco, E. Gouveia and F. Pa
reira 1953 O factor sanguineo Rh_0 (D) n
principais tribos da Guine Portuguesa. A
Inst. Med. Trop., *10:* 197–199.

Vandepitte, J., and J. DeLaisse 1957 Sickléni
et paludisme. Ann. Soc. Belge Med. Tro
37: 703–736.

Wahlund, S. 1928 Zusammensetzung von Po
ulationen und Korrelationserscheinungen v
Standpunkt der Vererbungslehre aus betrach
Hereditas, *11:* 65–106.

Wiener, A. S., L. J. Unger and E. B. Gordon 19
Fatal hemolytic transfusion reaction caused
sensitization to a new blood factor U. J. A
Med. Assoc., *153:* 1444–1446.

Zoutendyk, A. 1955 The blood groups of Sou
African natives with particular reference to
recent investigation of the Hottentots. Repo
and Communications of the Vth Internatio
Congress of Blood Transfusion, pp. 247–24

Incidence of Bifidity and Related Rib Abnormalities in Samoans

EDGAR J. MARTIN[1]
Toronto, Ontario, Canada

The incidence of rib abnormalities, as seen in chest films, is strikingly higher in Samoans than that reported in other populations. No reports on this peculiarity in Samoans have been found in the available literature. It was felt that precise data on this subject may be of interest to anthropologists, anatomists, and investigators of effects of ionizing radiation in the Pacific area. This cross sectional study was undertaken to provide a base line record of the findings and to consider possible causes of the condition.

MATERIAL AND METHODS

Demography

Samoa is an isolated archipelago in the South Pacific. The native inhabitants, numbering about 115,000 in 1956, are a self-contained ethnic unit belonging to the Polynesian race. Since the turn of the century the eastern islands of the archipelago have been under the administration of the United States of America, the western islands were first under Germany, but since World War I have been under New Zealand administration. This political division as yet has not appreciably affected the ethnic unity of the natives. The present study was made in American Samoa, and the subjects will be referred to as "Samoans." Tables 1 and 2 show the demographic situation of American Samoa.

Table 1 shows a rapid increase of the population since 1900. However, the increase concerns Samoans alone, as immigration is negligible. Non-Samoan residents represent only a small proportion of these figures, e.g., 3.3% at the 1956 census. In table 2 "part Samoans" are those who claim a non-Samoan among their ancestors.

At present there is little promiscuity between resident aliens and the natives, but it cannot be said what the situation was between 1942 and 1947 when tens of

TABLE 1

Census figures for the residents (Samoans, part Samoans and non-Samoans) of American Samoa from 1900 to 1956 (Pacific Island Yearbook, '56)

	Year of census				
	1900	1930	1940	1950	1956
Total population	5,697	10,055	12,908	18,937	20,154

TABLE 2

Samoans and part Samoans in American Samoa in 1956 by age groups (compiled from Census of American Samoa, '56)

	Age groups			Total
	Children < 10 yrs.	Adolescents 10–20 yrs.	Adults > 20 yrs.	
Samoans	6,299	4,434	7,228	17,961
Part-Samoans	586	427	505	1,518
Total	6,885	4,861	7,733	19,479

---

[1] Formerly with the Department of Medical Services, Government of American Saoma, Pago Pago, American Samoa. Present Address: 7 Edmund Avenue, Toronto, Ontario, Canada.

thousands of American soldiers were stationed on the islands. It is uncertain what proportion of the census claims are based on expediency. Such hybridization of Samoans as does occur is mostly with other Polynesians and with Caucasians. The proportion of part Samoans with modern Asiatic ancestry is negligible. There was no bias in the distribution of rib abnormalities in favor of subjects identified as part Samoans. For the statistics of incidence of rib abnormalities, the part Samoans were considered with the Samoans.

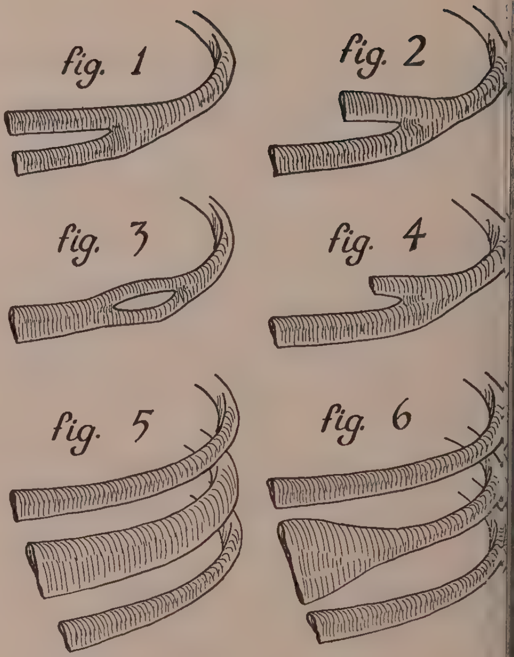
Screening

Posterior-anterior chest films, size 14 by 17 inches for adults and corresponding sizes for children, were screened to detect rib abnormalities. They had been taken with routine techniques for investigating soft tissue pathology. For this study only those films were used which allowed the viewing of the complete ribs I–VIII, in which recognition of the outlines of the ribs was not interfered with by soft tissue densities, technical mistakes, decalcification, or obesity of the subject, and in which no traumatic deformity was present. Cervical ribs and all abnormalities of ribs I–VIII were recorded. Special care was taken to avoid recording duplicate films.

Morphologic definition of rib abnormalities

In general we used the same definitions for the categories of abnormalities as Coury and Delaporte ('54). But since bifid ribs, spurs on ribs, and "wide" ribs were of major importance in our study, we attempted to define them with special accuracy.

Bifid ribs. Structures of the following shapes were pooled under this name: (1) bifid ribs in which the two branches were of about the same length, forming a U or V (cf. fig. 1), (2) bifid ribs in which one branch appeared up to two thirds shorter than the other (cf. fig. 2) and (3) forms "en anneau" (Pionnier and Depraz, '56) where a rib splits in two branches which further on rejoin each other and form a subsequent portion of rib of normal appearance (cf fig. 3). Failures of the investigator to notice bifidities are assumed to be rare.



Figs. 1–6 Aspects of bifid ribs, spurs on rib and wide ribs. Explanation in the text.

Spurs on ribs. Bifidities in which th length of one branch was less than on third of the other were called spurs (c fig. 4). When the height of a localize elevation of a border of a rib approache about one-fifth of the width of that rib it identification became doubtful and wa classified as a spur only on the groun of supporting morphologic particulariti such as cartilaginous and partly calcifie strands between the spur and the sternum widening of the intercostal space, a pr nounced angle in the rib at the location the spur, and an obvious abnormal ben in the adjacent rib.

The difficulty in identifying small spu limits the reliability of figures for th category. We assumed the weight of err to be negligible for ribs III–VIII but cou not properly estimate it for the ribs I an II. The projection of ribs I and II on t film may distort the appearance of the protuberances considerably. In additio in rib I the variability in size of sulci an tuberculi and calcifications of the tendo of the *m. scaleni* (Todd, '11) made it dif cult to determine what was a spur in th sense of bifidity. In ribs I and II only tho abnormalities which appeared very obvious were recorded.

Wide ribs. Ribs whose width was equal to or exceeded the combined widths of the two adjacent ribs were classified as wide ribs. This included ribs which were enlarged for varying portions of their length and ribs which fanned out in their distal portion (cf. figs. 5 and 6). We arbitarily neglected forms of transition between the "normal" and the defined width. With this qualification the recognition of wide ribs was assumed to be reliable for the ribs II-VIII. There was no good criterion to interpret variations in width of rib I. The few ribs I which appeared quite wide in the series of films were not recorded, since the weight of error could not be properly estimated. Wide ribs which carried a spur or a bifidity were recorded in the statistics as wide ribs.

Nomenclature

We assumed that bifid ribs (B), spurs on ribs (S), and wide or enlarged ribs (W) are morphologic modification of one and the same abnormality (Coury and Delaporte, '54; Pionnier and Depraz, '56). It will be designated hereafter as either BSW ribs or BSW abnormalities, depending on convenience. In compiling the statistics we neglected the possibility that a proportion of wide ribs may be unrelated to bifidity.

An abnormality was called "unicostal" when it occurred in a single rib per subject. Abnormalities were called "multicostal" when they occurred in more than one rib per subject.

Population samples

The Samoan material were chest films taken from January, 1956 till April, 1957. n the first place we screened films of adults who at that time had passed the age of 20 years. The films of 500 males and 500 females were studied in the order in which they had been taken. The adult Samoan series was compared with a control series of an adult non-Samoan population, using in both the same criteria of definition of abnormalities. For the control series the files of the Department of Radiology of the Cincinnati General Hospital, Cincinnati, Ohio, were available. Films taken in 1947 and 1948 were pulled at random from the filing shelves, and chest films of 500 male and 500 female adults over 20 years old were screened. According to the hospital records they were from Caucasians and Negroes in equal proportions in each sex. We neglected this detail since we were interested only in comparing a Samoan with a non-Samoan adult population sample. In both adult Samoan and Cincinnatian series consecutive films were arranged in five sequences of 100 for each sex.

In addition we screened a series of Samoan children and a series of Samoan adolescents, using what full size films were available. The incidence of BSW ribs in these two age groups was compared with that in Samoan adults.

RESULTS

In 1,000 chest films of adult Samoans 104 rib abnormalities were found. They were divided in four categories and their incidences were compared with those in three non-Samoan populations, namely the population sample of the Cincinnati General Hospital (hereafter referred to as "Cincinnatians"), and two European population samples. Pionnier and Depraz ('56), the author of the statistics on the European population samples, were the only ones in the literature whose screening methods for BSW ribs, synostoses, and agenesis are comparable to ours. They also gave adequate details of their definitions of these abnormalities so that we could extract statistics from their tables on the basis of our own criteria. The comparison is shown in table 3.

Table 3 shows the incidence of BSW ribs in adult Samoans is much higher than in adult Cincinnatians. The difference was found to be significant at the 1% level of P by the t test. The incidence of rib abnormalities of the other categories was about the same in Samoans and Cincinnatians. The two European population samples showed incidences of abnormalities similar to those of the Cincinnatians.

Statistics from other American and European population samples were obtained with screening techniques so different from ours that we could not use the figures for comparisons. However, none of them suggests an incidence of BSW ribs higher than that of the Cincinnatians (Pionnier and Depraz, '56).

TABLE 3

Mean incidence of rib abnormalities per 100 adults

The findings in Samoans are compared with those in each of three non-Samoan populations. The figures include all abnormal ribs regardless of whether they occurred as unicostal or multicostal abnormalities.

Population sample	Categories of rib abnormalities			
	BSW ribs	Synostoses	Agenesis	Cervical ribs
Samoans	9.4	0.0	0.4	0.6
Cincinnatians	2.2	0.3	0.2	0.7
Mixed Europeans[1]	1.8[1]	0.41[1]	0.47[1]	n.c.[2]
Scottish[1]	2.5[1]	+[3]	+[3]	+[3]

[1] Approximate figures are compiled from comments and tables from Pionnier and Depraz ('56).

[2] Differences in methods of detection make figures not comparable to ours.

[3] Figures not available. Other expressions are explained in the text.

TABLE 4

Distribution of 76 unicostal BSW[1] ribs which occurred in 500 male and 500 female adult Samoans for the ribs I–VIII, right and left side, and the two sexes

Rib	Males						Females						Total BSW ribs
	Right			Left			Right			Left			
	B	S	W	B	S	W	B	S	W	B	S	W	
I	–	1	–	–	–	–	–	1	–	–	–	–	2
II	–	1	–	–	–	–	–	–	–	1	–	–	2
III	3	2	2	1	4	–	3	–	2	2	1	1	21
IV	6	7	–	5	2	4	5	2	–	2	–	2	35
V	3	–	–	3	–	1	–	–	–	2	–	–	9
VI	2	–	–	2	1	–	1	–	–	–	–	–	6
VII	–	–	–	–	–	–	–	–	–	–	–	–	–
VIII	–	–	–	1	–	–	–	–	–	–	–	–	1
Total by sides		27			24			14			11		
Total by sexes				51						25			
Total							76						76

[1] The symbols B, S, and W are explained in the text.

Table 3 also shows that the incidence of rib abnormalities other than BSW were of the same magnitude in Samoans as in the other populations. Thus the incidences of different categories of rib abnormalities can vary idependently of each other. Further considerations are focused on the BSW abnormalities only.

Out of 1,000 adult Samoans 84 had BSW ribs. Seventy-six had unicostal and 8 had multicostal BSW abnormalities. A mean of 9.4 BSW ribs occurred per 100 subjects. The distribution of the BSW abnormalities is shown in tables 4 and 5.

Table 4 shows the distribution ratio for unicostal BSW ribs between males and females was 2.04. The significance of this sex difference as estimated by the Chi square test was at the 1% level of *P*. Table 5 shows no difference in the sex distribution for multicostal BSW abnormalitie The series of multicostal BSW abnorma ities was small as compared with the un costal series.

The combined figures of tables 4 and show 44.7% of the BSW abnormalities o curred in rib IV, 25.5% in rib III, an 29.8% in the remaining six ribs.

Table 6 shows the relative incidence combined unicostal and multicostal r abnormalities in adult Samoans.

Table 6 shows the distribution ratio b tween males and females was 1.89 for th first and 1.76 for the second column. Th significance of the sex differences as es mated by the Chi square test was at th 1% level of *P* in both columns.

Table 7 shows the distribution of th BSW ribs in the Cincinnatian series.

TABLE 5

Distribution between the ribs II–VII, right and left side, and sexes of 18 BSW[1] ribs which occurred as multicostal abnormalities in 4 male and 4 female subjects in a population sample of 500 male and 500 female adult Samoans

Side and rib	Male subject				Female subject				Total per rib
	No. 1	No. 2	No. 3	No. 4	No. 1	No. 2	No. 3	No. 4	
Right II	—	—	—	—	S	—	—	B	2
Right III	—	—	—	S	—	—	—	B	2
Right IV	—	S	W	—	—	B	—	S	4
Right V	B	—	—	—	—	—	B	—	2
Right VI	—	—	—	—	—	—	B	—	1
Left III	—	B	—	—	—	—	—	—	1
Left IV	S	—	S	—	B	—	—	—	3
Left V	S	—	—	—	—	—	—	—	1
Left VI	—	—	—	B	—	—	—	—	1
Left VII	—	—	—	—	—	B	—	—	1
Total		9				9			18

[1] The symbols B, S, and W are explained in the text.

TABLE 6

Relative incidence of BSW ribs in adult Samoans

Sex	Proportion of subjects having BSW abnormalities	Mean incidence of BSW ribs per 100 subjects
Males	11.0%	12.0
Females	5.8%	6.8
Combined sexes	8.4%	9.4

TABLE 7

Distribution of 22 unicostal BSW[1] abnormalities which occurred in 500 male and 500 female adult Cincinnatians for the ribs II–V, right and left side, and the two sexes

Rib	Males						Females						Total BSW ribs
	Right			Left			Right			Left			
	B	S	W	B	S	W	B	S	W	B	S	W	
II	–	–	–	–	1	–	–	1	–	–	1	–	3
III	–	–	2	3	–	–	1	–	–	1	1	1	9
IV	2	2	–	1	1	–	2	1	–	–	–	–	9
V	–	–	–	–	1	–	–	–	–	–	–	–	1
Total by sides		6			7			5			4		
Total by sexes				13					9				
Total							22						22

[1] The symbols B, S, and W are explained in the text.

Table 7 shows 2.2% of the Cincinnatian series had unicostal BSW abnormalities with 2.6% for the males and 1.8% for the females. No multicostal BSW abnormalities were detected. No BSW abnormalities were found in ribs I, VI, VII, and VIII. Otherwise the distribution patterns of table 7 show similar trends as those of table 4. Such differences as do appear between distribution patterns of the two tables cannot be interpreted because of the small numbers in table 7.

In the Cincinnatian series 6 male and 8 female Caucasians against 7 male and one female Negro had BSW abnormalities. A discussion of this distribution would be beyond the scope of the present study.

The incidence of BSW ribs was also studied in two additional Samoan age groups, namely children and adolescents. The findings are shown in table 8, and they are compared with those of Samoan adults in table 9.

TABLE 8

Incidence of BSW abnormalities in Samoan children less than 10 years old and in Samoan adolescents 10–20 years old

Sex	Children < 10 yrs. old			Adolescents 10–20 yrs. old		
	N[1]	Subjects having BSW ribs	Number of BSW ribs	N	Subjects having BSW ribs	Number of BSW ribs
Males	160	5	5	300	27[2]	32
Females	130	3[3]	4	200	8	8
Combined sexes	290	8[3]	9	500	35[2]	40

[1] Number of subjects screened.

[2] Four of these subjects had multicostal abnormalities with a total of 9 BSW ribs.

[3] One of these subjects had a multicostal abnormality with two BSW ribs.

TABLE 9

Proportion of subjects having BSW abnormalities in each of three age groups of Samoans, and (in parentheses) mean incidence of BSW ribs per 100 subjects

Sex	Children < 10 yrs. old	Adolescents 10–20 yrs. old	Adults > 20 yrs. old
	%	%	%
Males	3.12(3.12)	9.0(10.66)	11.0(12.0)
Females	2.31(3.08)	4.0(4.0)	5.8(6.8)
Combined sexes	2.75(3.10)	7.0(8.0)	8.4(9.4)

Table 9 is based on the figures of tables 6 and 8. It shows the incidence of BSW ribs in all categories of children is considerably smaller than in the corresponding categories of adults. For both males and combined sexes the differences were significant at the 1% level of *P* by the Chi square test.

The population sample of the children included 56 children less than two years old, but we did not detect any BSW ribs in their chest films.

Of the 116 BSW ribs in the adult Samoan and Cincinnatian population samples, 114 originated in the ventral half of ribs and only two, both of them in Samoans, in the dorsal half. One of the latter was a widening, apparently on the entire right rib V, and suggested a modified development of duplication of that rib.

There did not seem to be any correlation between BSW ribs and any other disorder (Rist et al., '28). Among the 1,790 Samoans of all age groups we found the following rare conditions: a duplication of the right rib IX in a healthy 17-year-old male, a duplication of the right rib VIII in a newborn female who was debilitated and died four days after birth, and a neo-arthrosis between the dorsal thirds of the right ribs VI and VII in a 6-year-old female. One of the carriers o BSW ribs was a 25-year-old male who ha cleft palate and mental deficiency.

DISCUSSION

Abnormalities of the ribs, sternum, an vertebrae are caused by a variety of mechanisms, e.g., lumbar and cervical ribs result from incomplete resportion of embryonic ribs (Todd, '11); Warkany ('51) observed a variety of congenital deformitie of ribs in animals born from mothers wh had nutritional deficiencies during the pregnancy; vitamin deficiencies may caus the human ribs and sternum to acquire abnormal shapes after birth (Weinmann an Sicher, '55); occupational hazards inhe ent to a pattern of culture and superimposed perhaps on hereditary factors a thought to cause the high incidence o spondylolisthesis in some Eskimo group (Stewart, '53); abnormal contours an general development of the human r I are interrelated with abnormal morpho ogy of soft structures in the vicinity, an in general morphologic features of an bone are related to neighboring parts the skeleton (Todd, '12).

The factors which are involved in th formation of BSW ribs in general and their high incidence among Samoan adul n particular are unknown. It is also unknown whether all BSW ribs are caused by one and the same set of factors.

On the grounds of analogies one could speculate about them as follows:

Congenitality. BSW ribs are commonly referred to as congenital. However, we could not find in the literature that any attempt has ever been made to investigate whether the condition is present at or develops after birth. From the figures in tables 8 and 9 it appears that BSW abnormalities may not be present at birth. However, they may escape recognition in infants and children. Screening of chest films may not be an adequate technique for detecting BSW ribs in children, as spurs on ribs may be too small to be noticed. Terminal clubbing of ribs is common in Samoan children, but we cannot determine which have the potentiality of becoming BSW ribs at a later date. BSW structures which may be present but not yet calcified do not show on the routine x-ray film.

Commenting further on table 9, a correlation between incidence of BSW ribs and change in age would be acceptable in a cross sectional study only if changes in other independent variables did not interfere with the population in an unpredictable manner. Such interference is suspected in the Samoans, since they are in a state of rapid change in many sectors of life, such as nutrition, medical care, occupational habits, and communications. The effect of these changes on the formation of BSW abnormalities can be assessed only by studies repeated at intervals (Trotter and Gleser, '58).

Whatever the comments may be, neither the literature nor our tables 8–9 present any evidence for BSW ribs being congenital.

Genetic factors. The high incidence of an abnormality in a fairly homogenous population and a 2:1 distribution between males and females suggest a sex-influenced genetic pattern. The smallness of our insular Samoan population and the paucity of its contacts with other races prior to the year of birth of the youngest of our adult subjects suggest environmentally induced endogamy as an additional factor. Unfortunately, the local conditions made attempts to establish genealogic trees unsuccessful, and the possibility of genetic patterns in the occurrence of BSW ribs could not be explored.[2]

Infectious, metabolic, or mechanical trauma. A number of infectious and parasitic diseases in all age groups and primary and secondary nutritional deficiencies in infancy and childhood are endemic in Samoa.[3] It is unknown if any of them, or mechanical stresses and injuries by occupational habits or unsuspected rituals inherent to the Samoan culture, may cause BSW ribs. It is also unknown whether exposure of pregnant mothers to any of the above categories of trauma may cause BSW ribs to develop in the fetus or child (Cohn, '32).

Hypothesis of sternal developmental abnormalities. There is no evidence for bifidity, increased width, or spurs being caused by factors within the ribs. Todd ('12) showed abnormal processes in the vicinity of ribs can cause the ribs to develop into abnormal shapes. Mayet (1895) showed abnormalities of growth rate occur sometimes in the sternum. It can be speculated that this may affect the shaping of true, vertebrocostal ribs in the following manner. During a period of development the longitudinal growth rate in a portion of a sternal bar may significantly exceed the normal growth rate of the width of the corresponding rib. The soft tissues of the rib and its cartilage would then be stretched in a vertical plane, become bifid or abnormally wide, and later calcify in this shape. The mechanics involved may recall those which sometimes cause ribs to regenerate in bizarre shapes after chest operations. The following observations are consistent with this hypothesis:

---

[2] Birth registers in Samoa are unreliable; adoption (Mead, '28) still plays an important role in the Samoan culture, and the natives are either unable or unwilling to distinguish relationship by birth from that by adoption. Information given by Samoans is customarily based on expediency and often contradictory and an apparently high degree of promiscuity makes information about mates unreliable. All these factors make the value of genealogic investigation by interview doubtful.

[3] Yaws which used to be highly endemic (index about 100%) was eradicated with a penicillin campaign in 1947/49 in those islands which are under American administration, and similar action was under way about 8 years later in the islands under New Zealand administration. Intestinal parasitism, predominantly ascariasis, is still highly endemic, and so is filariasis Bancrofti, though in recent years blood filaria is becoming rare in the urban area of Pago Pago. A kwashiokor-like nutritional deficiency is prevalent. Its incidence is said to fluctuate with time and locality.

(1) BSW abnormalities lie in the plane of the thoracic wall and seem integrated in its functions. (2) The forms which are variously described as "fanning," "flaring," or "en spatule" are particularly revealing. They consist of a spatula-like widening of the terminal inch or so of the rib at the costochondral junction (cf. fig. 6). This fanning is in some cases just a widening of the rib, but in other cases it shows all degrees of transition to bifidity. The fanning suggests that the terminal perichondrium, periosteum, and soft tissues of the rib were spread in a vertical plane when they were still uncalcified. This process may have taken place for a relatively short period during the development of the subject and been followed by a period of normal growth and calcification of the rib tissue. The later in life the spreading occurs, the closer to the costochondral junction the BSW abnormality would be in the adult. (3) The finding that the origin of BSW abnormalities is located mostly in the ventral half of the rib, and only very rarely in the dorsal half, points also at a sternal factor in the formation of these abnormalities and is consistent with the view that a proportion of them develop in childhood and puberty.

The hypothesis postulates that the longitudinal growth rate of the portion of the sternal bar opposite the potential BSW rib is significantly greater than the rate in adjacent portions of the sternal bar. Such localized imbalances in sternal growth rates may be either genetically controlled (Ashley, '56) or caused during the postnatal development by metabolic (Herdner, '47) or mechanical trauma.

The finding of a bifid rib VIII in an adult Samoan suggests that mechanisms which are not controlled by sternal factors may also cause BSW abnormalities. It can be also speculated that abnormal sternal growth events may enhance the penetrance (Kühne, '34) of an heritable trait of duplication of ribs.

Conclusions. The causes and mechan
isms of formation of BSW ribs ar
unknown, and the findings that this abno
mality occurs in adult Samoans signif
cantly more frequently than in other adu
populations remains unexplained. Th
working hypothesis that a proportion o
BSW abnormalities may be related to al
normal events primarily taking place i
the sternum may be useful in future in
vestigations. The investigations shoul
focus on factors affecting the developmen
of the sternum. The frequency distribu
tion of the BSW abnormality suggests
further narrowing of the area to be in
vestigated, namely the sternal portion
which are opposite or adjacent to th
sternal joints of ribs III and IV, the factor
which concern males more than female
and the factors which occur in childhoo
and puberty rather than in infancy an
fetal life. Techniques other than routin
chest films will be required for such an in
vestigation.

There is also the possibility that basic
ally we are dealing with an incomplete du
plication of the ribs that is geneticall
controlled. An investigation of this aspec
of the problem must, however, await th
time when dependable family pedigree
can be assembled and analyzed.

SUMMARY

Bifid ribs (B), spurs on ribs (S), an
wide ribs (W) are thought to be a series o
morphologic modifications of one abno
mality and are called BSW ribs here. Ches
films of 1,000 adult Samoans showe
8.4% of this population sample have BS
ribs, 11.0% of the males and 5.8% of th
females. Some of the abnormalities o
curred multicostal, and the mean inci
ence of BSW ribs was 9.4 per 100 subject
12.0 for males and 6.8 for females. Thes
figures are significantly higher than thos
in American and European poulation sam
ples. Statistics on BSW ribs must b
treated separately from those of othe
categories of rib abnormalities.

There is no evidence as to whethe
BSW ribs are present at birth or develo
later in life, and the factors involved i
their formation are unknown. The po
sible role of genetic, epidemiologic, nutr
tional, and cultural factors in the caus

ion of the high incidence of BSW ribs in amoans could not be investigated.

It is speculated that BSW abnormalities re not necessarily caused by growth fac- ors within the ribs. In the true ribs they nay result from the stretching, in a ver- ical plane, of the distal soft rib structures vhen longitudinal growth of portions of he sternum occurs at uneven rates tem- orarily. Such events may occur during ostnatal life rather than during fetal life. 'uture investigations should use tech- iiques other than the screening of routine" chest films.

ACKNOWLEDGMENTS

The author is indebted to Mr. C. Lincoln, dministrator of the Hospital of Pago 'ago, American Samoa, to Dr. B. Felson,)epartment of Radiology, Cincinnati Gen- ral Hospital, Cincinnati, Ohio, and to the taff of the Division of Thoracic Surgery f the Toronto Hospital of Tuberculosis, Veston, Ontario, for making their files of hest films available; and to Dr. J. W. A.)uckworth and Dr. J. E. Anderson, De- artment of Anatomy, University of To- onto, for valuable advice in writing this aper.

LITERATURE CITED

shley, G. T. 1956 The relationship between the pattern of ossification and the definitive shape of the mesosternum in man. J. Anat., *90:* 87–105.

'ensus of American Samoa 1956 Government of American Saoma Printing Office, Pago Pago.

Cohn, I. 1932 Skeletal disturbances and anomalies. Radiology, *18:* 592–626.

Coury, C., and J. Delaporte 1954 Les anomalies congénitales des côtes. Sem. Hôp. Paris, *30:* 2656–2681.

Herdner 1947 Le sternum de l'enfant. J. Radiol. Électrol., *28:* 387–393.

Kühne, K. 1934 Symetrieverhältnisse und die Ausbreitungszentren in der Variabilität der regionalen Grenzen der Wirbelsäule des Menschen. Ztschr. Morph. u. Anthropol., *34:* 191–206.

Mayet, M. 1895 Recherches sur l'ossification du sternum chez les subjets normaux et chez les rachitiques. Bull. Soc. Anat. Paris, *70:* 381–384.

Mead, M. 1928 Coming of Age in Samoa. New York.

Pacific Islands Yearbook 1956 Pacific Publ. Pty. Ltd. Sydney.

Pionnier, R., and A. Depraz 1956 Les anomalies costales d'origine congénitale. Radiol. Clin. Basel, *25:* 171–186.

Rist, E., L. Gally and C. Trocmé 1928 L'ossification des cartilages costaux dans l'espèce humaine. Pr. Méd., *36:* 641–644.

Stewart, T. D. 1953 Age incidence of neural-arch defects in Alaskan natives. J. Bone Jt. Surg., *35A:* 937–950.

Todd, T. W. 1911 The relation of the thorax operculum considered in reference to the anatomy of cervical ribs. J. Anat., *45:* 293–304.

——— 1912 Costal anomalies of the thoracic inlet. Anat. Anz., *41:* 257–271.

Trotter, M., and G. C. Gleser 1958 A re-evaluation of estimation of stature based on measurements of stature taken during life and of long bones after death. Am. J. Phys. Anthrop., n.s., *16:* 79–123.

Warkany, J. 1954 Disturbances of embryonic development by maternal vitamin deficiencies. J. Cell. and Comp. Physiol. (suppl. 1), *43:* 207–236.

Weinmann, J. P., and H. Sicher 1955 Bone and Bones, 2nd ed. C. V. Mosby, St. Louis.

Blood Group Frequencies in New Guinea

I. THE BLOOD GROUPS OF THE ASMAT PAPUANS

L. E. NIJENHUIS[1], TH. BEKKERS AND J. L. DE VRIES[2]
Central Laboratory of the Netherlands Red Cross Blood Transfusion Service, Amsterdam, Holland[3] and Public Health Service, Hollandia, Dutch New Guinea[4]

The lowlands along the coast of south New Guinea, between the Charles-Louis mountains and the Eilanden River are inhabited by tribes, speaking languages that are related to each other. Drabbe ('53) mentions three different language groups: the Kamoro-, the Sempan and the Asmat languages.

The Kamoro language is spoken from the Opa River (134° 45′ Eastern Length) until the Karamuga River (137° Eastern Length). The number of Kamoro speaking Papuans is about 7,000–8,000. Drabbe distinguished 6 different dialects within this language. Often the Kamoro region is called the Mimika district, the mouth of the Mimika River being the government center of the region. East of the Kamoro region a few small tribes (about 900 Papuans) speak the Sempan language, which is related to the Kamoro language. East of this we find another related language, the Asmat language. This Asmat region is situated between the Helwig River and the Kampong River. It is not known how large the population is, but it is at least 20,000. The Asmats are cannibals, whereas the Western Kamoros are not. They live in a closed village-community. There has been only little contact between the different villages. Family relationships do exist with members of other villages due to the stealing of women and children when opportunity occurs. The greater part of the people however marry partners from their own village.

MATERIAL AND METHODS

One hundred and fifty-two blood samples were taken in the village of Sjoero, next to Agats at the Flamingo Bay. When the blood was collected the village counted 688 inhabitants. It was tried to avoid taking blood samples from closely related persons. For the techniques of taking and transporting blood may be referred to a previous paper (de Vries and Nijenhuis, '60). The Asmat blood samples had to be sent by boat to Merauke and were transported by air via Hollandia and Biak to Amsterdam. It was not always possible to replace the ice in the container when it was melted.

Blood group tests were performed in Amsterdam 10 and 11 days after taking the samples. By that time most of the samples were beginning to hemolyse, however only 5 samples gave panagglutination and had to be eliminated. Tests were done with the following antisera: anti-A, -B, -A+B, -M, -N, -P, anti-C, -c, -D and -E, 100 samples were tested with anti-Fy^a, 105 with anti-He and 90 with anti-S.

RESULTS

The observed frequencies are listed in the tables. The following observations are striking. The high A and B frequencies, the very low M frequency and especially the very high frequency of CDe.

As in previous studies with Papuans (de Vries and Nijenhuis, '60) no Duffy negatives and Henshaw positives were observed. The P-frequency is about the average that has been found so far in New Guinea. The percentage of S-positives is higher than has been found in other parts of Dutch New Guinea (de Vries and Nijenhuis, '60

---

[1] Biologist, Central Laboratory of the Netherlands Red Cross Blood Transfusion Service, Amsterdam, Holland.

[2] Government Medical Officer, Dutch New Guinea.

[3] Director: Dr. J. J. van Loghem Jr.

[4] Director: Dr. J. Bierdrager.

TABLE 1

	Observed		Expected		Gene-frequencies	
	Number	%	Number	%		%
O	35	23.81	35.0	23.8	O	48.8
A	55	37.415	55.1	37.5	A	29.5
B	38	25.85	38.1	25.9	B	21.7
AB	19	12.925	18.8	12.8		
Totals	147	100.00	147.0	100.0		100.0
M	0	0.00	0.1	0.1	M	2.72
MN	8	5.44	7.8	5.3	N	97.28
N	139	94.56	139.1	94.6		
Totals	147	100.00	147.0	100.0		100.00
MMS	0	0.0	0.00	0.00	MS	0.0
MMss	0	0.0	0.13	0.15	Ms	3.9
MNS	1	1.1	0.52	0.58	NS	7.5
MNss	6	6.7	6.22	6.91	Ns	88.6
NNS	12	13.3	12.47	13.86		
NNss	71	78.9	70.65	78.50		
Totals	90	100.0	89.99	100.00		100.0
P+	86	58.5			P	35.6
P−	61	41.5			p	64.4
Totals	147	1000				100.0
CCDee	145	99.3			CDe	99.66
CcDE	1	0.7			cDE	0.34
Totals	146	100.0				100.00
Fy(a+)	100	100.0			Fy^a	100.0
Fy(a−)	0	0.0			Fy^b	0.0
Totals	100	100.0				100.0
He+	0	0.0				
He−	105	100.0				
Totals	105	100.0				

and Simmons, Graydon, Semple and Swindler, '56) but lower than in Australian New Guinea where, except in the Gorokas of the central highland, always more than 10% of S-genes were found (Simmons et al., '56). When comparing the results of the Asmats with those of other Papuan populations, similarities with some parts of the south coast of Australian New Guinea were observed (Simmons, Graydon, Woods, Smith and Lancaster, '46).

Daru and Kikori (gene frequencies):

A	18.2%
B	19.6%
O	62.2%
M	3.9%
N	96.1%

Daru, Kikori and others:

CDe	94.5%
cDE	2.0%
cDE	2.0%
CDE	1.5%

High frequencies of B, N and CDe ha also been found here. High CDe, A and frequencies were also observed in Chiml Papuans from the Central Highlands Australian New Guinea (Semple, Si mons, Graydon, Randmae and Jamieso '56). When comparing the ABO freque cies in the Asmats with other south coa populations of Dutch New Guinea, seems, that Bylmer ('35) also found high A frequency (29.3%) in the Mimi district (Kamoro). However the B-fr uency is much lower, only 9.9%. East of smat, in Merauke, Kalthofen (cited by ylmer, '35) found low frequencies for oth genes A and B (14 and 11%). When omparing however the Asmats with the her Papuan populations the possibility ust be considered that the extreme freuencies observed in Sjoeroe may be at ast partly due to genetic drift or other auses.

SUMMARY

One hundred forty-seven blood samples om the village Sjoeroe in the Asmat gion of south west New Guinea were sted for blood group frequencies. The sults show very extreme frequencies for ome blood groups. Very high frequencies f the genes A, B, N and CDe were obrved.

ACKNOWLEDGMENT

Our thanks are due to Dr. O. Kranenonk, Public Health Service, New Guinea, ho assisted in collecting the blood sames, to Dr. R. T. Simmons, Melbourne, Australia, for his critical remarks, and to Dr. Ph. Levine, Raritan, N. J., U.S.A., and Dr. A. E. Mourant, London, who provided us with samples of anti-Di^a and anti-S.

LITERATURE CITED

Bylmer, H. J. T. 1935 Bloedgroep en ras. Ned. Tijdschr. Geneesk., *79:* 2738–2755.

Drabbe, P. 1953 Spraakkunst van de Kamoro taal. Koninklijk Instituut voor taal-, land- en volkenkunde, 's Gravenhage.

Semple, N. M., R. T. Simmons, J. J. Graydon, G. Randmae and D. Jamieson 1956 Blood group frequencies in natives of the Central Highlands of New Guinea, and in the Bainings of New Britain. Med. J. Austr., *2:* 365–371.

Simmons, R. T., J. J. Graydon, E. F. Woods, W. A. H. Smith and H. O. Lancaster 1946 Further observations on the Rh and Hr factors and the blood group frequencies in Papuans. Ibid., *1:* 537–539.

Simmons, R. T., J. J. Graydon, N. M. Semple and D. R. Swindler 1956 A blood group genetical survey in West Nakanai, New Britain. Am. J. Phys. Anthrop., n.s., *14:* 275–286.

De Vries, J. L., and L. E. Nijenhuis 1960 Blood group frequencies in New Guinea. I. The Sentani Papuans. Am. J. Phys. Anthrop., n.s., *18:* 125–130.

Blood Group Frequencies in New Guinea

III. BLOOD GROUPS OF THE NIMBORAN PAPUANS

L. E. NIJENHUIS[1] AND J. L. DE VRIES[2]
Central Laboratory of the Netherlands Red Cross Blood Transfusion Service, Amsterdam, Holland[3] and Public Health Service, Hollandia, Dutch New Guinea[4]

The Nimboran district of Dutch New Guinea in the western part of the Grime-plain, is inhabited by some thousands of Papuans. The Grime-plain is situated south west of Lake Sentani and Hollandia.

The foundation of the administration and mission in this area took place in the years of 1917–1925. The population is subdivided into a great number of little clans ("tangs"). Before the pacification each of those tangs inhabited its own, fortified village, mostly situated on top of the hills south of the Grime-plain, each consisting of about 20–30 families. People do not marry within their own tang and each tang has family relations with a great number of other tangs. Formerly friendly relations existed with the eastern tribes

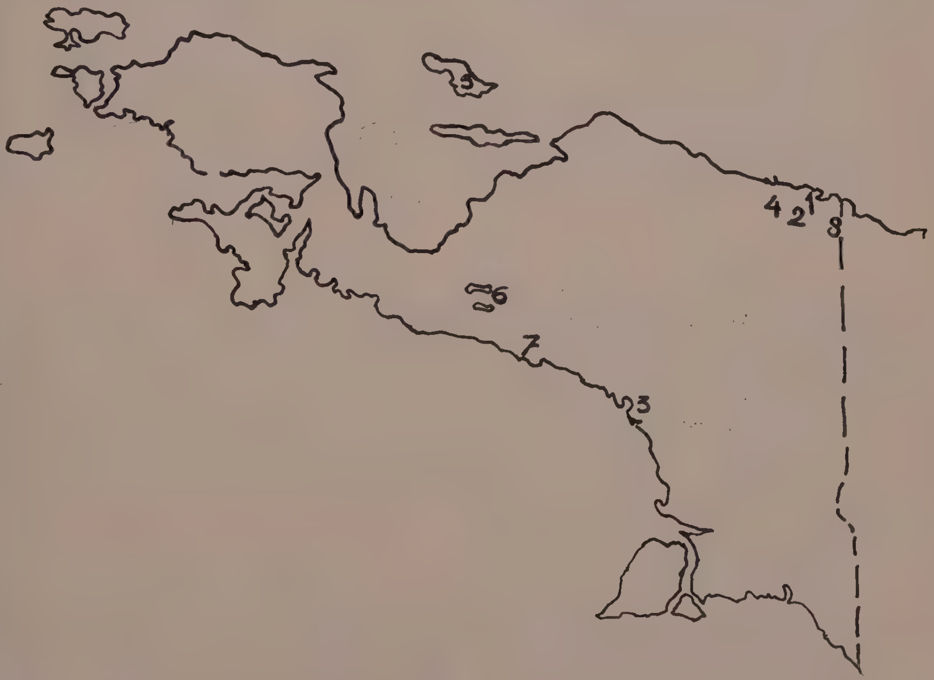


Fig. 1 Dutch New Guinea; districts referred to in the paper. 1, Sentani: referred to in Part I, III; 2, Sekori: referred to in Part I, III; 3, Asmat: referred to in Part II; 4, Nimboran: referred to in Part III; 5, Biak (Schouten Islands): referred to in Part I; 6, Wissel lakes: referred to in Part I; 7, Mimika district: referred to in Part I, II; 8, Jafi district referred to in Part I.

---

[1] Biologist, Central Laboratory of the Netherlands Red Cross Blood Transfusion Service, Amsterdam, Holland.

[2] Government Medical Officer, Dutch New Guinea.

[3] Director: Dr. J. J. van Loghem Jr.

[4] Director: Dr. J. Bierdrager.

(Gressie, Kamtuk, Mungge) while the Nimborans and their Western neighbors (Japsi, Sawé) lived in constant hostility.

Except for little differences between groups of tangs the Nimborans are an entity in many respects. This must probably be the reason why they claim a collective descent from an ancient Gressie Settlement in Nimboran. However it is more probable that the Nimboran population originates from intensively mixed elements from several tribes.

MATERIAL AND METHODS

In December, 1957 a serological investigation for yaws was performed. When collecting the blood, from 132 samples 4 drops were added to 0.5 ml Rous-Turner citrate-glucose solution. These blood samples, meant for blood group research, were stored in a refrigerator until they were packed in a thermos flask with ice for transportation by air. When collecting the material close family relations were avoided; this has been successful in the first degree and in all probability also in the second degree.

Blood groups were determined in the laboratory in Amsterdam 14 days or less after collecting the blood. Five samples were not used because of a weak autoagglutinability of the red cells.

RESULTS

Tables 1–4 show the frequencies of the blood groups observed in the remaining 127 blood samples. The samples that were found to react positively with anti-A serum were also tested with anti-A_1. Though some blood samples gave only weak reactions with this serum no negatives (A_2 or A_2B) were found, as could be expected from a Papuan population.

Ten negative reactions were found with anti-D, used in the saline technique. About the same number of samples gave a weak reaction. The negative ones were re-examined with an incomplete anti-D serum that was known to have a high activity when used in the Coombs technique, against D^u antigens. In this way all these 10 samples proved to carry a D^u antigen. The occurrence of D^u antigen has been discussed more extensively in a previou paper (de Vries and Nijenhuis, '59).

When comparing the observed frequen cies with those of other populations of th same area, the Nimborans show significan differences with the Sentani papuans a well as with the inhabitants of the Seko plain (table 5). The differences in th frequencies of the ABO blood groups ar not significant (χ^2 2.09 and 3.91 for d.f.); whereas in the MN and the Rhesu systems significant differences were ob served.

	MN
Nimboran-Sentani	χ^2 15.46 for 1 d.f. $P < 0.1$
Nimboran-Sekori	χ^2 12.97 for 1 d.f. $P < 0.1$
	Rhesus
Nimboran-Sentani	χ^2 19.30 for 3 d.f. $P < 0.1$
Nimboran-Sekori	χ^2 6.06 for 1 d.f. $P < 2$

Though the differences are significan it seems that Nimboran and Sekori hav the same tendencies especially in the R systems: a very high percentage of CD very little cDe and low or very low cD frequencies. As the population of such small region is heterogeneous, it does n seem opportune to make comparisons wit populations of completely different par of New Guinea before much more is know about the distribution of the blood grou all over New Guinea.

SUMMARY

Blood group frequencies were dete mined in 127 unrelated Nimboran Pap ans. The results are given in the tab 1–4. A rather high frequency of D^u was o served. Comparing the observed freque cies with those of some neighborin populations the differences proved to significant in the MN and Rh systems.

ACKNOWLEDGMENTS

Our thanks are due to Dr. O. Krane donk, Public Health Service, New Guine who assisted in collecting the blood sa ples, to Dr. R. T. Simmons, Melbourn Australia, for his critical remarks, and Dr. Ph. Levine, Raritan, N. J., U.S.A., a Dr. A. E. Mourant, London, who provid us with samples of anti-Di^a and anti-S.

TABLE 1

	Observed		Expected		Gene frequencies	
	Number	%	Number	%		
						%
O	59	46.5	59.4	46.8		
A	49	38.6	48.5	38.2	O	68.4
B	15	11.8	14.3	11.3	A	23.8
AB	4	3.15	4.7	3.7	B	7.8
Totals	127	100.05	126.9	100.0		100.0

TABLE 2

	Observed		Expected		Gene frequencies	
	Number	%	Number	%		
						%
M	0	0.0	0.07	0.06		
MN	6	4.7	5.95	4.68	M	2.4
N	121	95.3	120.98	95.26	N	97.6
Totals	127	100.0	127.00	100.0		100.0
MS+	0	0.0				
MS−	0	0.0				
MNS+	0	0.0			MS	0.0
MNS−	6	5.6			Ms	2.8
NS+	0	0.0			NS	0.0
NS−	101	94.4			Ns	97.2
Totals	107	100.0				100.0

TABLE 3

	Observed		Gene frequencies	
	Number	%		
				%
P+	69	56.1	P	33.8
P−	54	43.9	p	66.2
Totals	123	100.0		100.0

TABLE 4

	Observed		Expected		Gene frequencies	
	Number	%	Number	%		
						%
CCDee	107	81.9	104.2	82.1		
CcDE	21	16.5	20.8	16.4	CDe	90.6
CcDee	1	0.8	0.9	0.7	cDE	9.1
ccDEE	1	0.8	1.05	0.8	cDe	0.4
Totals	127	100.0	126.95	100.0		100.1

TABLE 5

	Gene frequencies							
	O	A	B	M	N	CDe	cDE	cDe
Sentani	72.4	18.9	8.7	11.0	89.0	80.4	12.1	7.5
Sekori	59.9	29.9	10.2	9.7	90.3	95.7	4.3	0.0
Nimboran	68.4	23.8	7.8	2.4	97.6	90.6	9.1	0.4

LITERATURE CITED

Kouwenhoven, W. J. H. 1956 Nimboran, a study of social development in a New Guinea society. Thesis, Leiden.

de Vries, J. L., and L. E. Nijenhuis 1959 Blood group frequencies in New Guinea. I. The Sentani papuans. Am. J. Phys. Anthrop., n 18: 125–130.

Nijenhuis, L. E., T. Beckers and J. L. de Vri 1959 Blood group frequencies in New Guine II. The blood groups of the Asmat papua Am. J. Phys. Anthrop., n.s. 18: 189–192.

Blood Groups in Sephardic Jews

E. MARGOLIS, J. GUREVITCH AND D. HERMONI
Outpatient Department "C," Hadassah-University Hospital, and Department of Clinical Microbiology, Hadassah-University Hospital and Hebrew University-Hadassah Medical School, Jerusalem, Irael

Sephardic Jews are the descendants of the Jews who were expelled from Spain in 1492 and from Portugal in 1497, and who settled in all parts of the Ottoman Empire.

There is no definite proof of the existence of Jews in Spain in the early centuries of the Christian Era (Baer, '43). From the official prohibition proclaimed at Illiberis in A.D. 306, it may be deduced, that in the time of the Vandal and Visigothic rule there were already Jewish settlers in Spain, who lived in peace with the Gentiles and even intermarried.

Later, after the Arab conquest, many Jews of Asia and Africa, who had served in the Arab armies, settled in Spain. Part of Castile, for example, was conquered by Berber Jews of Morocco, under the leadership of Kaulan al-Yahudi (Mezan, '43).

There was also emigration. The frequent persecution of the Jews in Spain during the Arab rule often ended with part of them emigrating to North Africa. Large scale migration commenced with the massacres and persecutions of 1391, which were followed by forcible mass conversions in 1412 to 1415.

The total expulsion of Spanish Jewry in 1492 followed by those from Portugal in 1497, caused an overflow of Jewish migration into southern France, Holland, Italy, North Africa, Turkey and Asia Minor.

With so extensive geographical and political distribution, with "their thirst for knowledge together with the fact that they associated freely with the outer world" (Kayserling, '05) it was only natural that the character of the cultural, economic and social life of the Sephardic Jews developed great heterogeneity (Neuman, '43).

Nevertheless there were certain common traits of language, religious customs and general demeanor. In all parts of the world they retained "Ladino" (Judaeo-Spanish) as the language of speech and as a literary medium. Wherever they settled they retained their own customs and religious traditions, which often differed from the practices of the indigenous Jewish communities. They founded their own congregations and communal organizations. Social prestige and intense self-consciousness caused the Sephardim to keep aloof from their fellow Jews of German or Polish origin and there was little intermarriage with them.

The present study is concerned with Sephardic Jews from the Balkan countries who came to Israel between the years 1949–1957.

METHODS

The methods of blood group typing and the antisera used are as previously described (Gurevitch and Margolis, '55).

RESULTS AND DISCUSSION

The distribution of the ABO phenotypes and the respective genes are summarized in table 1.

An interesting feature is the high frequency of the phenotype A (45%) which is the highest figure so far found in the Jewish communities studied by us. It is of interest that a frequency of about 42% A was also found in some populations of the Balkan peninsula, e.g., Turks, Serbians and Bulgarians (Mourant, '54).

In a previous study (Gurevitch, Hermoni and Polishuk, '51) the percentage of the O group in Sephardic Jews was found to be 40.5. This result may have been affected by the fact that the group studied was heterogeneous, including Jews from North Africa (Algiers, Tunis, Morocco), southern Europe (Bulgaria, Greece) and an indigenous group from Israel.

TABLE 1

ABO blood groups in Sephardic Jews

Blood group	No. obs.	Frequency observed	Frequency expected	No. expected	Gene frequency
O	59	29.50	29.34	58.68	p = 32.15
A	90	45.00	45.17	90.34	q = 13.68
B	33	16.50	16.69	33.38	r = 54.17
AB	18	9.00	8.80	17.60	
Total	200	100.00	100.00	200.00	100.00

TABLE 2

MN blood groups in Sephardic Jews

Blood group	No. obs.	Frequency observed	Frequency expected	No. expected	Gene frequency
MM	20	15.00	25.00	50.00	M = 50.00
MN	140	70.00	50.00	100.00	N = 50.00
NN	30	15.00	25.00	50.00	
Total	200	100.00	100.00	200.00	

TABLE 3

MN blood groups in two Sephardic subgroups

	No. obs.	Phenotypes (no.)			Phenotypes (%)		
		MM	MN	NN	MM	MN	NN
From Turkey	112	13	82	17	11.60	73.20	15.20
From Bulgaria	70	10	48	12	14.30	68.60	17.10

In the present study the frequency of the O phenotype is rather low (29.5%), in comparison with the figures obtained for Moroccan (37.7%) and Tunisian Jews (39.5%). If it is assumed that the high group O frequency indicates a Berber influx in these Jewish communities, it may be that this North African component has penetrated only to a limited extent, in spite of the frequent contact over the cenuries.

The phenotype B was found in Sephardic Jews at a frequency of 16.0% which is lower than that encountered in the population of North Africa—Berber and Arab. This, too, might be taken as an indication of less than average North African admixture.

The M and N genes are evenly distributed in the Sephardic Jews (table 2). The phenotype distribution, however, shows an interesting phenomenon, namely the unusually high percentage of 70 for the MN phenotype. These results are confirmed by separate examination of the two main subgroups. As may be seen from table 3, the percentage for the MN phenotype was 73.20 in Sephardic Jews fro Turkey and 68.60 in Sephardic Jews fro Bulgaria. In this respect the Sephardi stand out from the other Jewish com munities so far studied. Whether this i heterosis and thus a reflection on th heterogeneity of the Sephardic Jews d veloped in their cultural, economic an social life, remains a problem open t speculation.

Table 4 shows the distribution of th blood groups of the Rh-Hr system.

The highest figure was obtained for th CDe, the so-called "Mediterranean" chr mosome (45.75), which was characteri tically high in all Jewish communitie studied by us (Margolis, Gurevitch an Hasson, '57). The same observation wa stressed by Mourant ('54) and sugges the common Mediterranean origin of th Jewish people.

The chromosome cde follows with a hig frequency of 26.57%. This chromosome found more in the heterozygous stat while the homozygous ccddee phenoty is infrequent (7%) as found in som Oriental Jewish communities, e.g., Bag

TABLE 4

Rh-Hr blood groups in Sephardic Jews

Blood group	No. obs.	Frequency observed	Frequency expected	No. expected	Chromosome frequency
CCDE	2	1.00	0.96	1.92	
CCDee	54	27.00	26.03	52.06	
CCddE	—	—	—	—	
CCddee	—	—	0.31	0.62	CDE 0.93
CcDE	21	10.50	11.22	22.44	CDe 45.75
CcDee	70	35.00	35.61	71.22	Cde 5.57
CcddE	—	—	0.10	0.20	cDE 9.23
Ccddee	6	3.00	2.96	5.92	cdE 0.94
ccDE	18	9.00	8.19	16.38	cDe 11.01
ccDee	14	7.00	7.06	14.12	cde 26.57
ccddE	1	0.50	0.51	1.02	
ccddee	14	7.00	7.06	14.12	
Total	200	100.00	100.01	200.02	100.00

ladi, Kurdistani and Persian Jews (Gurevitch and Margolis, '55; Gurevitch, Hasson and Margolis, '56). The high level of cde may be due to the acquisition of a Basque component or of a Berber component from North Africa (Mourant, '54).

The chromosome cDe, characteristically high in all populations of Africa (Mourant, '54), was found in the Sephardic Jews to be 11%. This is somewhat higher than that encountered in Moroccan and Tunisian Jews (Margolis, Gurevitch and Hasson, '57). How has this chromosome penetrated the Sephardic stock? According to Mourant ('54) this component was presumably acquired mainly in Egypt and elsewhere in North Africa, but some may have come through Spain, where raised cDe frequencies are found in several regions. The latter seems most probable, as no other indications were found to suggest the permeation of considerable North African elements in Sephardic Jews.

SUMMARY

ABO, MN and Rh-Hr blood group frequencies in 200 Sephardic Jews from the Balkan States are reported and compared with findings in other Jewish communities in Israel.

ACKNOWLEDGMENTS

Thanks are due to Dr. R. Moab, Department of Botany, the Hebrew University, Jerusalem, for the statistical work-up of the data. We are greatly indebted to Dr. Ada C. Kopec, of the Nuffield Blood Group Centre, for checking the results of the statistical calculations.

LITERATURE CITED

Baer, F. 1943 The Universal Jewish Encyclopedia. New York, *9:* 684.

Brzezinsky, A., J. Gurevitch, D. Hermoni and G. Mundel 1952 Blood groups in Jews from the Yemen. Ann. Eugen., *16:* 335.

Gurevitch, J., D. Hermoni and Z. Polishuk 1951 Rh blood types in Jerusalem Jews. Ibid., *16:* 129.

Gurevitch, J., and E. Margolis 1955 Blood groups in Jews from Iraq. Ann. Hum. Genet., *19:* 257.

Gurevitch, J., E. Hasson, E. Margolis and C. Poliakoff 1955 Blood groups in Jews from Cochin, India. Ibid., *19:* 254.

Gurevitch, J., E. Hasson and E. Margolis 1956 Blood groups in Persian Jews. Ibid., *21:* 135.

Kayserling, M. 1905 The Jewish Encyclopedia. New York, *11:* 199.

Margolis, E., J. Gurevitch and E. Hasson 1957 Blood groups in Jews from Morocco and Tunisia. Ann. Hum. Genet., *22:* 65.

Mezan, S. 1943 The Universal Jewish Encyclopedia. New York, *9:* 683.

Mourant, A. E. 1954 The Distribution of the Human Blood Groups, Blackwell Scientific Publications, Oxford, pp. 72–74.

Neuman, A. 1943 The Universal Jewish Encyclopedia. New York, *9:* 477.

lood Groups in Ashkenazi Jews

E. MARGOLIS, J. GUREVITCH AND D. HERMONI

Outpatient Department "C," Hadassah-University Hospital, and Department of Clinical Microbiology, Hadassah-University Hospital and the Hebrew University-Hadassah Medical School, Jerusalem, Israel

The term Ashkenazim is used to denote ne of the great divisions of Jewry in conradistinction to the Sephardim (Spanish ews) and the Oriental Jews, from whom hey differ in many respects.

The Ashkenazim include the descendnts of the German and French Jews, who, fter the crusades and subsequent persecuions in Germany and after the expulsions rom France, migrated into Prussia, Poand, and other countries of northern, cenral and eastern Europe, as well as the ajority of Jews now residing in the mericas, England and South Africa.

Anthropologically the Ashkenazim differ rom the Sephardim and their oriental rethren: they have a larger proportion of londs, have rounded faces and heads and re shorter especially in comparison with he Sephardim.

Ashkenazim originally spoke middleigh German, which later remained exlusively with the Jews who were shut up n the Ghetto, and was afterwards carried y migratory Jews into Poland, Russia and astern Europe. In course of time this udaeo-German became interspersed with ebrew and Slavonic words, and it surives to this day in the form of Yiddish Revel, '39).

The present study is concerned with shkenazim from Europe who immigrated nto Israel during the years 1949–1957.

METHODS

The methods of blood group typing and ntisera used in the present study were he same as previously described (Gureitch and Margolis, '55).

RESULTS AND DISCUSSION

The distribution of the ABO blood groups ound in Ashkenazim is given in table 1. hese results are very similar to figures obtained in a previous study (Gurevitch, Hermoni and Polishuk, '51).

The Ashkenazi Jews are characterized by a very high frequency of the phenotype A—40.22%. Of the 8 oriental Jewish communities already examined by us, none reached this high level. In the Yemenite Jews, for example, only 30% of A group has been found. In the Cochin region of India, the so-called "black Jews" have a very low A group percentage, 14.9%. On the other hand, a 45% frequency of A group has been recorded in Sephardic Jews (Margolis, Gurevitch and Hermoni, in press), which is close to the figure found in Ashkenazim.

The Jews examined in Canada (Chown, Peterson, Lewis and Hall, '49), probably mainly Ashkenazim, have A and B gene percentages of 29 and 11, which are also close to the figures cited in table 1. Raised A and B levels are considered characteristic for the European Jews (Mourant, '54).

The frequency of the O gene in Ashkenazim was found to be 61.70% and thus they should be included in the 60–65% zone, to which large parts of Europe belong (Mourant, '54; Manuila, '56).

The figures for the M and N genes (table 2) are 53.55 and 46.45 respectively, and are similar to those found in many European populations (Mourant, '54).

On the other hand, our figures are also close to the results encountered in Moroccan and Tunisian Jews (Margolis, Gurevitch and Hasson, '57), but differ from those found in most oriental Jewish communities (Gurevitch, Hasson, Margolis and Poliakoff, '55a; '55b; Gurevitch, Hasson and Margolis, '56).

The distribution of the Rh-Hr chromosomes are listed in table 3. The figure for the so-called Mediterranean chromosome CDe is high, 52.23%, and close to the

TABLE 1

ABO blood groups in Ashkenazi Jews

Blood group	No. obs.	Frequency observed	Frequency expected	No. expected	Gene frequency
O	177	38.06	38.32	178.19	p = 26.57
A	187	40.22	39.95	185.77	q = 11.53
B	74	15.91	15.60	72.54	r = 61.90
AB	27	5.81	6.13	28.50	
Total	465	100.00	100.00	465.00	100.00

TABLE 2

MN blood groups in Ashkenazi Jews

Blood group	No. obs.	Frequency observed	Frequency expected	No. expected	Gene frequency
MM	126	27.10	28.68	133.36	M = 53.55
MN	246	52.90	49.75	231.34	N = 46.45
NN	93	20.00	21.58	100.35	
Total	465	100.00	100.01	465.05	

TABLE 3

Rh-Hr blood groups in Ashkenazi Jews

Blood group	No. obs.	Frequency observed	Frequency expected	No. expected	Chromosome frequency	
CCDE	2	0.43	0.44	2.05		
CCDee	125	26.88	27.66	128.62	CDE	0.42
CCddE	—	—	—	—	CDe	52.23
CCddee	—	—	—	—	Cde	0.36
CcDE	59	12.69	12.07	56.13	cDE	11.10
CcDee	179	38.49	37.52	174.47	cDe	5.25
CcddE	—	—	—	—	cde	30.64
Ccddee	1	0.22	0.22	1.00		
ccDE	40	8.60	9.20	42.78		
ccDee	16	3.44	3.49	16.23		
ccddE	—	—	—	—		
ccddee	43	9.25	9.39	43.66		
Total	465	100.00	99.99	464.94		100.00

levels encountered in other Jewish communities living in the Mediterranean zone. In Moroccan and Tunisian Jews, for example, the frequency of this chromosome was found to be 53.40 and 56.09% respectively (Margolis and Gurevitch, '57). The Ashkenazim, however, have a much higher frequency of the so-called "North European" chromosome, cDE (11.10%). According to Mourant ('54) this is what would be expected in a Medditerranean population which has acquired a considerable local component during residence in central and northern Europe. Interestingly enough, high figures for this chromosome were found also in some oriental Jewish communities, and the question was then raised as to the origin of this chromosome in these communities (Gurevitch, Hasso and Margolis, '56).

The frequency of the cde chromosom is 30.64%. This is higher than the frequencies encountered in most, althoug not in all, oriental Jewish communitie (Gurevitch, Hasson and Margolis, '56 The cde chromosome is relatively rare i its homozygous combination, the frequenc of the Rh negative phenotype in the Ashkenazim being 9.39%, lower than the percentage found in the European countrie which fall mostly in the 12–16% zone.

The Ashkenazim, with 5.25% cDe diffe considerably from their Sephardic (11% Moroccan (9.45%), Tunisian (8.47% and Tripolitanian (9.46%) brethre This is not surprising if it is recalled tha he cDe chromosome comes from African r Spanish sources (Mourant, '54).

SUMMARY

ABO, MN and Rh-Hr blood group fre- uencies in 465 Ashkenazi Jews from Euro- ean countries are reported and compared vith findings in other Jewish communities n Israel.

ACKNOWLEDGMENTS

Thanks are due to Dr. R. Moab, Depart- nent of Botany, the Hebrew University, erusalem, for the statistical work-up of he data. We are greatly indebted to Dr. da C. Kopec, of the Nuffield Blood Group entre, for checking the results of the tatistical calculations.

LITERATURE CITED

rzezinsky, A., J. Gurevitch, D. Hermoni and G. Mundel 1952 Blood groups in Jews from Yemen. Ann. Eugen., *16:* 335.

Chown, B., R. F. Peterson, M. Lewis and A. Hall 1949 On the ABO gene and Rh chromosome distribution in the white population of Manitoba. Canad. J. Res., *E27:* 214.

Gurevitch, J., and E. Margolis 1955 Blood groups in Jews from Iraq. Ann. Hum. Genet., *19:* 257.

Gurevitch, J., D. Hermoni and Z. Polishuk 1951 Rh blood types in Jerusalem Jews. Ann. Eugen., *16:* 129.

Gurevitch, J., E. Hasson, E. Margolis and C. Poliakoff 1955a Blood groups in Jews from Cochin, India. Ann. Hum. Genet., *19:* 254.

——— 1955b Blood groups in Jews from Tripolitania. Ibid., *19:* 260.

Gurevitch, J., E. Hasson and E. Margolis 1956 Blood groups in Persian Jews. Ibid., *21:* 135.

Manuila, A. 1956 Distribution of ABO gene in eastern Europe. Am. J. Phys. Anthrop., *14:* 577.

Margolis, E., J. Gurevitch and E. Hasson 1957 Blood groups in Jews from Morocco and Tunisia. Ann. Hum. Genet., *22:* 65.

Margolis, E., J. Gurevitch and D. Hermoni 1960 Am. J. Phys. Anthrop., *18.*

Mourant, A. E. 1954 The Distribution of the Human Blood Groups. Blackwell Scientific Publications, Oxford, pp. 72–74.

Revel, H. 1939 The Universal Jewish Encyclopedia. New York, *1:* 541.

Revaluation of Age, Stature and Sex of the Tepexpan Remains, Mexico[1]

SANTIAGO GENOVÉS T.
Instituto de Historia, Universidad de Mexico, Mexico City, Mexico

This paper will not review or evaluate what has been written about the possible affinities of the Tepexpan remains in the well-known work by de Terra, Romero and Stewart ('49). It will, however, touch upon three points already analyzed in that memoir; that is, age, stature and sex, data that are of importance for whatever final interpretation may be made of the Tepexpan specimen.

Due to my particular interest in matters of sex, stature and age in present-day human specimens as well as in those of a certain antiquity, I undertook to revise these aspects, as no other publication on physical anthropology, to the best of my knowledge, had come out since 1949, in which a first-hand study of the material had been made. Let it be clear that although the material examined now is the same as in 1949, 10 years have gone by full of many valuable new contributions related to the points examined at present. Therefore that I arrive at different conclusions than Romero did 10 years ago, in no way detracts from the merit of his study.

Because of the nature of the paper the Results and the Discussion will be included jointly for each section (age, stature, sex) with a partial conclusion relating to each of these points.

MATERIALS AND METHODS

On February 22, 1947 Helmut de Terra and R. V. Arellano discovered in the process of excavating in what is known as the "Valley of Mexico," the remains of what has been named thereafter "Tepexpan man." "The village of Tepexpan lies at the base and on the promontory of a basaltic lava flow which projects from an old volcanic cone into the valley basin. The highway to the pyramids of Teotihuacán skirts this promontory 7 km distant from Route 1 (Laredo highway) or some 34 km from Mexico City" (De Terra, Romero and Stewart, '49, p. 22). A fuller description of the interesting circumstances leading to the discovery of the human remains is given in the above mentioned publication, as well as an account and estimation of the many sided aspects of its anthropological importance.

The human remains found in 1949 and kept now at the Museo Nacional de Antropología are as follows:

Cranium. Vault complete. Base fragmented but almost complete: three fragments of sphenoid bone; left petrous portion; basilar part including the occipital condyles.

Face. Frontal process of maxilla. Nasal bones. Fragment of right and left maxilla. Fragment of left molar. Alveolar margin of maxilla. Palate. Fragment of left orbital plate.

Mandible. Lacking condyles and posterior portion of right ascending ramus. Four unidentified small fragments.

Vertebrae. Nine fragments, among which is an almost complete epistropheus.

Ribs. Five fragments, seemingly belonging to different ribs.

Pelvis. Small fragment of innominate. Small fragment of sacrum.

Upper extremities. Middle portion of right and left clavicles; right acromial extremity and a small fragment of right scapula. Shafts of right and left humeri and a fragment of the head of the humeri. Right and left ulnae with the proximal end present only in the right ulna. Right radius almost complete and the left one lacking proximal end.

---

[1] Paper presented to the Fifth International Congress of Prehistorical and Protohistorical Sciences, held in Hamburg, August 1958.

Hand bones. Ten metacarpals. First, second, 4th and 5th right first phalanges. Third left first phalanx. Third, 4th and 5th right second phalanges. Fourth, and 5th left second phalanges. First, second and 5th right third phalanges. First left third phalanx.

Lower extremities. Shafts of right and left femora and the left distal extremity separate. Three fragments of the distal end of right femur. Right and left patellae. Right and left tibial shafts. Nine fragments of the proximal ends of the tibiae. Fragment of distal extremity of the tibia. Three fragments of fibular shafts.

Foot bones. Right and left talus. Right cuboid. Left second cuneiform. First and 5th metatarsal bones. Left first, second and 4th first phalanges. Eight unidentified fragments.

Unidentified fragments when the present inventory was made. Eighty-eight small fragments. Forty larger fragments.

From these, J. Romero based his study of "The Physical Aspects of Tepexpan Man" on pp. 87–118 of the 1949 publication and I this revaluation.

RESULTS AND DISCUSSION

Age

The age of the Tepexpan remains (1949) was based on (a) the degree of sutural obliteration, determined ecto- and endocranially, (b) the degree of dental attrition and (c) the density of the bone tissue, observed in the mandible and the maxilla by direct appreciation and by x-ray.

On the first point, Romero ('49) followed the opinion of Newman; we quote pp. 97–98: "Standards for endocranial and ectocranial closure are those of T. W. Todd. Since they are based on a male, white dissecting-room population, their application to American Indians is probably not wholly valid. Observations were made in strong natural light under a magnifying glass."

"The coronal, sagittal, and lambdoid sutures are completely closed. On the basis of Todd's standards, Tepexpan Man was more than forty-eight years old. Both portions of the spheno-temporal are still open, which would make the specimen less than sixty-seven years old. However, the inferior portion of the masto-occipital suture and the greater wing of the spheno-frontal suture are closed. These reach a peak of closure at seventy-two and sixty-five years respectively, but in individual cases may close earlier."

"Since the standards are not wholly satisfactory and the margin of error relatively great in aging skulls of advanced age fifty-five to sixty-five years is the present best estimate." Furthermore, along this same line, Romero (de Terra, Romero and Stewart, '49, p. 95) points out that the basi-sphenoid suture is closed, and that any trace of it has vanished. However, over this point, Moss ('59, personal communication) does not appear to be entirely in agreement. It is evident, therefore, that the most precise bases used for diagnosis ('49) is the degree of suture obliteration.

On the basis of the studies of Todd and Lyon ('24–'25), I would not quite agree in fixing the age between 55 and 65. I would reduce the estimate in some years.[2] However, this would be futile since the studies by Senyürek ('47), Vandervael ('52), Singer ('53), Cobb ('55), Thompson, Brooks ('55), McKern and Stewart ('57) and Cabot Briggs ('58) all—except that of Senyürek—on modern skulls of diverse origins, indicate that the diagnosis arrived at by means of suture closure, almost completely lacks any practical utility. In individual cases the margin of error goes far beyond acceptable limits. In a series of 101 Mexican skulls studied, we (Genovés and Messmacher, '59) concluded: "The difference between the average estimated ages and the real age, is however too great: (11 years one month for the whole series: 9 years 5 months for mestizos, 12 years 11 months for 'indians'). This is due to the lack of agreement between the traditional patterns and the actual age." And farther on: "Having estimated the possibilities of the cranial sutures (coronal, sagittal and lambdoid) and some other characteristics (see conclusion 11), we have tried with the highest rigor possible, to arrive at satisfactory results. It must be admitted, that unfortunately, this has not been possible, and that, with the mentioned estimates, any pretension of relative exactness in the assignment of age by means of cranial sutures is without bases in at least 50% of the cases." In the light of these post-1949 studies I feel that the suture criteria must be discarded.

---

[2] In a recent study (Genovés and Messmacher, '59) have concluded that two years and 6 months is the approximate average of divergence in the estimations of the various investigators in a series of Mexican skulls.

With reference to the degree of dental abrasion, it is well known that its usefulness for these purposes is quite unreliable. Vallois already stated ('37, p. 501): "Le degré d'usure des dents ne peut donc servir de critérium pour l'estimation dé l'âge des Hommes fossiles: on verra plus loin qu'a diverses reprises, on a écrit que des crânes appartenaient a des sujets tres vieux du seul fait que leurs dents étaient tres usées. *Il ne faudra attacher aucune valeur a ces affirmations.*" (My italics.)

Reviewing some aspects of the Chancelade remains the same author ('41–'46, p. 169) insists: "L'usure des dents est extrementent marquée, mais j'ai dit ailleurs que ce caractère n'a absolument *aucune valeur pour l'estimation de l'âge individual des hommes fossiles.*" (My italics.) Gustafson ('50) is of the same opinion.

Genovés and Messmacher ('59) tested the value of abrasion and some other characteristics (condition of the condyles, pathology, etc.) in Mexican crania, and independently arrived at the following conclusions: "We can say, with reference to morphological observations, that up to the present we have no assurance in regard to the age of approximately half of the cases, and that in the other half we would estimate the error between ± 4 and ± 7 years, which is not very encouraging."

I find myself, therefore, forced to abandon these criteria for the age diagnosis of the Tepexpan remains.

Fastlich (de Terra, Romero and Stewart, '49, p. 128) says: "As a result of the foregoing, we may infer that the loss of the teeth took place at different periods of the life of the individual, which is confirmed by the fact that in the upper jaw the region corresponding to the right premolars, as well as that belonging to the second left

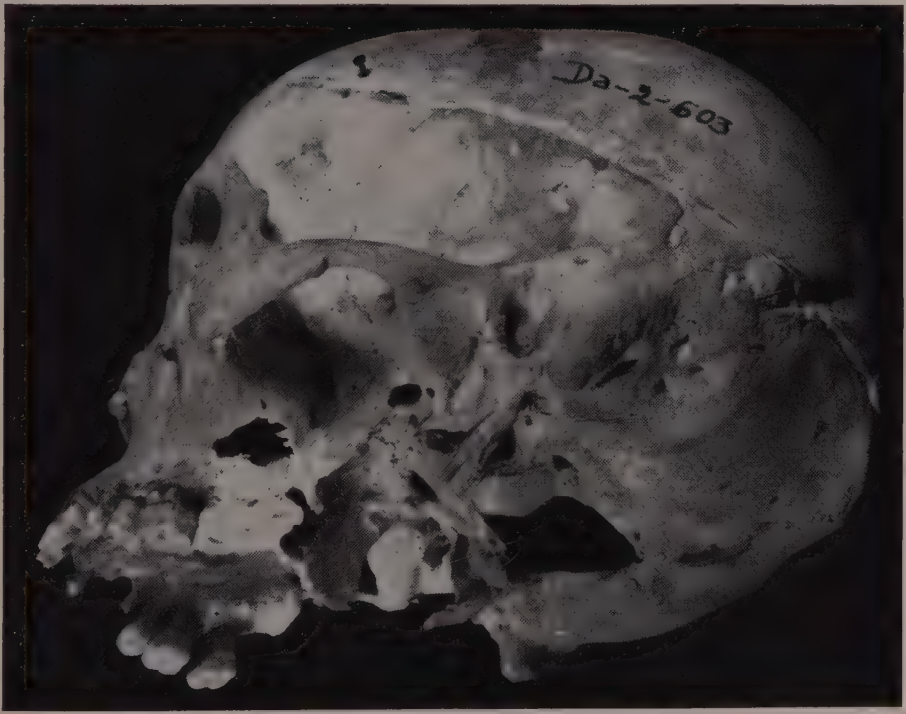


Fig. 1 Specimen of 22 years 9 months.

molar, is more calcified than the other zones of the same jaw. The region of the lower jaw which corresponds to the molars of both sides is entirely ossified, which likewise shows that the individual lost the mentioned teeth long before his death.”

I am of the opinion that the total ossification of the region of the mandible corresponding to the molars does not necessarily indicate that the individual lost the teeth “long before his death.” If the intense attrition harmed the pulp and consequently led to alveolar abscesses, the loss of the molars could have been early and also, therefore, the process of reabsorption. Without any special knowledge or particular studies on the subject I consider that the opinion, based on the dental argument, that Tepexpan is an individual of “advanced age” is not entirely justified. Figures 1, 2, 3, 4, 5 are photographs of adult individuals (maxillas and mandibles), much younger that the proposed 55 to 65 years for Tepexpan, in which, however, a total reabsorption of the dental alveoli can be appreciated. Moss ('59, personal communication) seems to have obtained radiographic data, complemented with direct observation of the Tepexpan mandible that supports our “rejuvenation” of the remains.

With reference to the obliteration of the basi-sphenoid suture, the latter indicates that the individual was, at least, more than 20 years of age, but that is all.

The slight exostosis which is observed in the atlas and axis, also is not necessarily indicative of age. It is slight, and not appreciable on the bodies of the other two existing cervical vertebrae nor on the small portion of the sacrum. I therefore consider that this should not be taken into account in the form that Stewart ('57) has pointed out for other material.

In short: from the data offered in 1949 it seems today that on the remains themselves there is no evidence—particularly in the light of some studies made after that date—that the age of the Tepexpan specimen could lie between 55 and 65 years; it only can be said that is was an adult of more than 20 years of age.

It seems pertinent to mention that Tepexpan is not the only example of certain antiquity who has had his age “reduced.” Testut (1889) gave to Chancelade a range of 50 to 70 years, and Vallois ('41–'46)

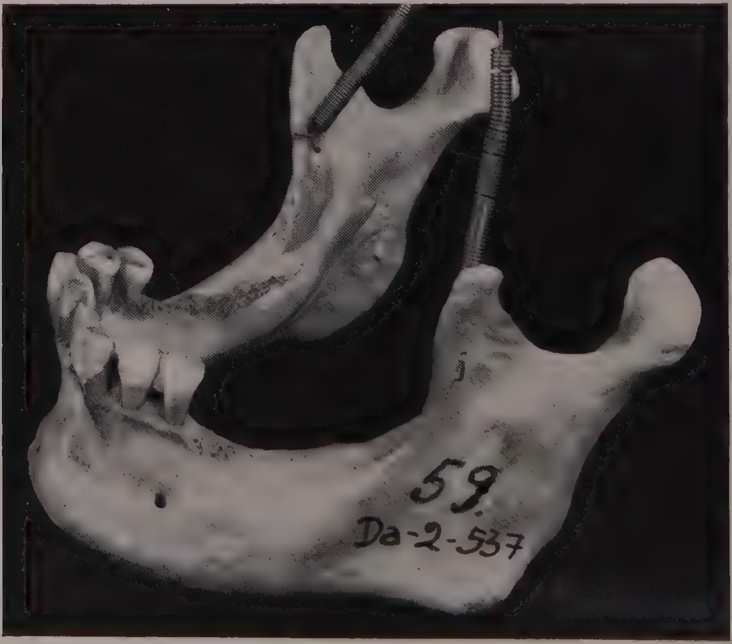


Fig. 2 Specimen of 31 years 6 months.

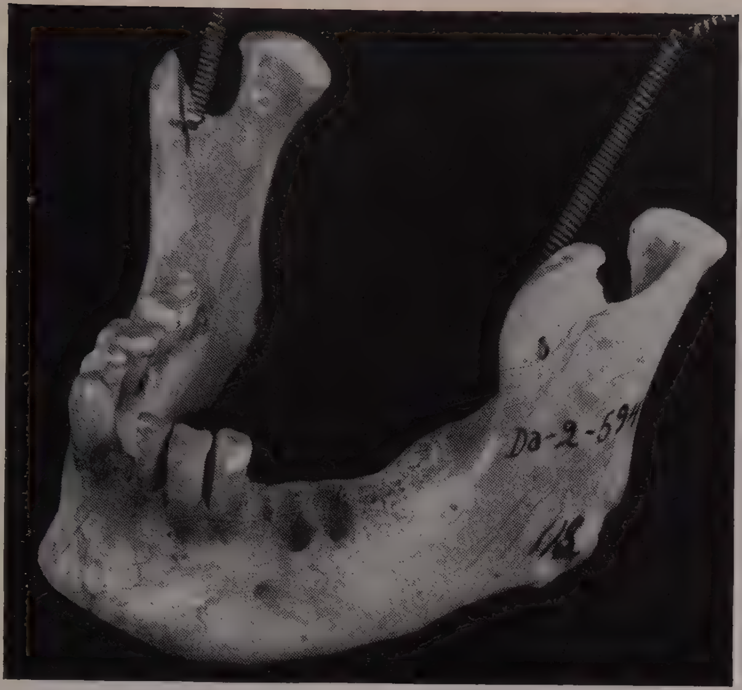


Fig. 3 Specimen of 22 years 4 months.

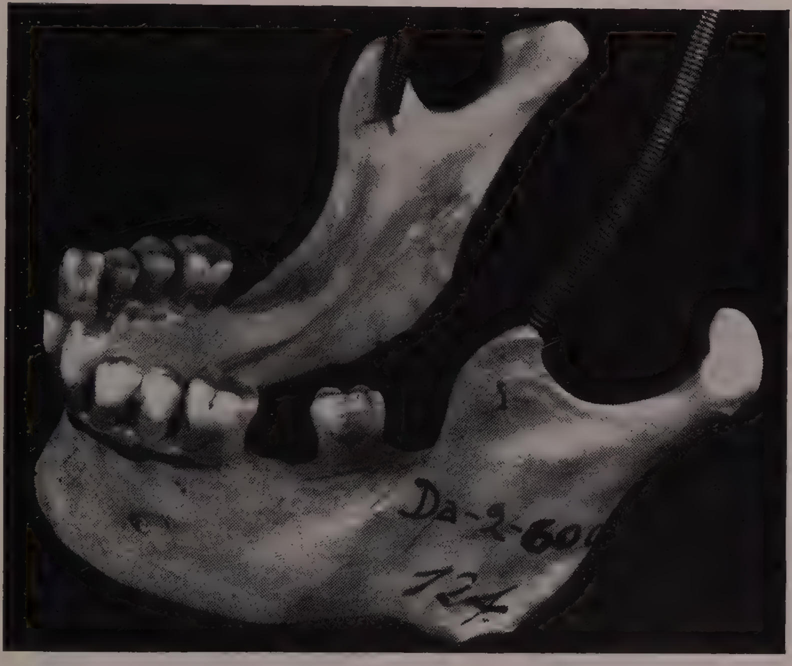


Fig. 4 Specimen of 21 years 8 months.

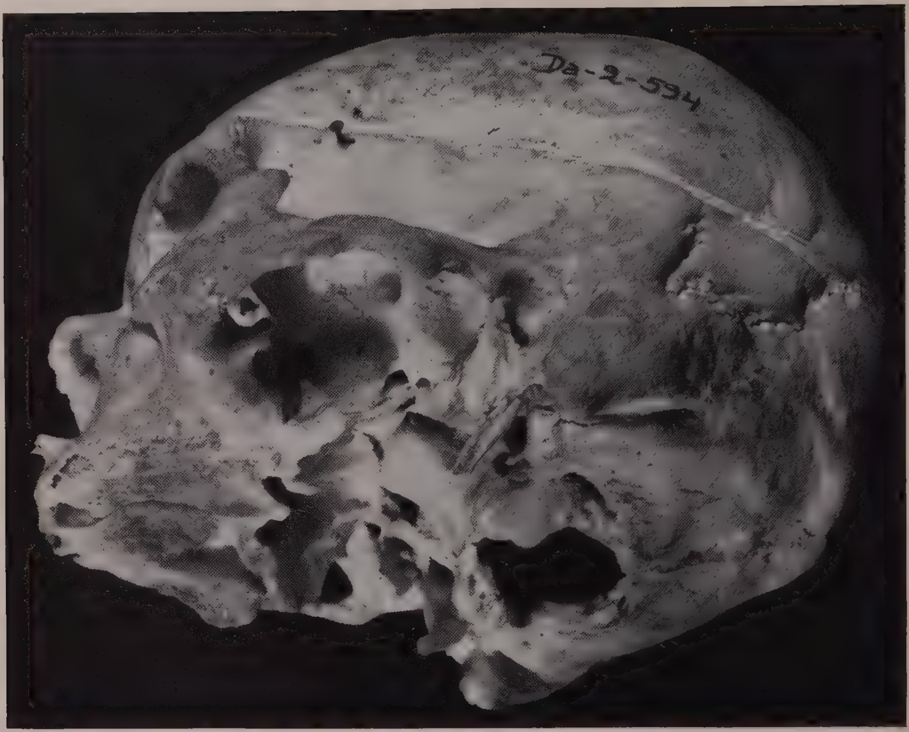


Fig. 5 Specimen of 22 years 4 months.

only around 40 years. This last author did the same with Cromagnon I, II and III and with other remains whose ages had been overestimated. What is more, recently I have postulated it will happen likewise with Fontéchevade II (Comas and Genovés, '59, pp. 40–42).

I shall now present some direct and indirect data that leads me to think that the age was much below that assigned until now.

Although I do not know of any really specialized studies on the subject, Testut ('28), Augier ('32) and Goldstein ('36) among others, have dealt with the transformations which, due to age, are observed on the skeleton. In an individual between 55 and 65 years of age there should be found on the skull and especially on the mandible, those characteristics which point towards the senile state: thinning of the diploe which produces consequently a thin cranial wall, slight deformations in the neighborhood of the parietal bosses, irregular osseous conglomerations, mainly in the endocranium—and particularly in the frontal bone—and a marked wear on the few articular surfaces available for study.[3] None of the preceding are found in Tepexpan, nor any other characteristics in the long bones that could lead to believe that the specimen was old or even rather old.

Romero's ('49) estimation of stature is 1.70 m and he considers 1.60 and 1.62 m as the mean statures for pre-Columbian and modern males respectively, in these regions. Now, in order to arrive at the 1.70 m estimate—with which I am not entirely in agreement as shall be shown presently—Manouvrier's tables (1892 and 1893) were preferentially used. Manouvrier says that the effects of age operate in such a manner that individuals of approximately 60 years of age, have lost 3 cm from their maximum stature (see also

---

[3] Although we have proved the irregularity of this appreciation in the occipital condyles (Genovés and Messmacher, '59), its utilization could be of service.

Trotter and Gleser, '51; Hooton and Dupertius, '51; Lasker, '53 and Lee and Lasker, '58). If these 3 cm are added we have 1.73 m. Romero gives as possible for Tepexpan between 1.67 and 1.73 m. If to the maximum the 3 cm are added the value obtained is rather unrealistic. That is, if the Tepexpan specimen died at 60 years of age, he measured 1.73 m when young, which is, in fact, a highly improbable stature. On the other hand, if the remains were of between 25 and 30 years of age at the time of death, as I postulate, then it was in the period of maximum stature, and 1.70, minus the reduction that I shall discuss later, is a more reasonable and realistic stature. This agrees with Stewart (de Terra, Romero and Stewart, '49) who states (p. 126): "My impression was however that the individual could not have been very tall," and 1.70 m for Tepexpan is indeed very tall. In other words, if the specimen died at 60 years, it attained a stature rarely reached in these parts, which is indirect proof that the remains were not 60 years of age at the time of death, but instead, very close to the age of maximum stature.

Let us pass now to the problem of the possible duration of life of remains of certain antiquity, whose environmental conditions may have been, along general lines, equivalent to those of Tepexpan.

From the upper Paleolithic of Europe, only 1% (Obercassel) of the specimens among 102 studied by Vallois ('37) reached an age over 50 years (table III, p. 520, Vallois, '37).

According to the same author, among the Neandertal group only one out of 20 subjects were found to be between 41 and 50 years of age and three more (15%) between 31 and 40 years of age (table II, p. 512, Vallois, '37).

From the Mesolithic, two subjects among 60, (3%) reached an age above 50 years, and one subject (1.5%) reached an age between 41 and 50 years (table IV, p. 524, Vallois, '37). It must be pointed out that although Vallois used then the suture criteria as a base, many of these remains have also postcranial elements that fundamentally do not contradict Vallois' percentages.

Todd ('27) fixed 30 years as the age of maximum mortality among West-African natives, and between 15 to 25 years of age for a small series of Tasmanian skulls. On his part, Fusté ('54, p. 83) finds that in the Spanish neo-eneolithic "(a) the highest mortality among both sexes corresponds to the ages between 20 and 40 years and, (b) the scarce frequency of longevity." The works of Senyürek ('47 and '51), Sauter ('47–'48 and '48–'49) and of Goldstein ('53) point in the same direction.

From table 1 (Fusté, undated reprint, p. 328) the comparatively small possibility that Tepexpan has, from the demographic point of view, of having reached the age of 60 years, in contrast with some modern populations, can be appreciated.

Conclusion about age

I have analyzed the problem of the age directly in the remains, and indirectly, in relation to other individuals that lived in a more or less equivalent environment. I do not consider from any point of view, that there exist valid reasons for assigning to the Tepexpan remains an age above that of 30 years.

Stature

As it has already been indicated, Romero ('49) arrived at the conclusion that the stature of the individual was possibly between 1.67 and 1.73 m. Since the mean of 4 estimations gives 169.5 cm, he considered 170 cm as the acceptable average. I quote from page 99 ('49): ". . . so the problem is to determine which procedure is to be considered best and whether more reliance should be put on figures derived from one complete bone or on those derived from the reconstruction drawings of all of them." Pearson (1898) had already pronounced himself in favor of the first method: "one or two organs well selected are worth much more for prediction than a much longer number selected less carefully."

It happens that in Tepexpan, the right ulna and radius are practically complete and are, therefore, two of the bones used for the reconstruction of stature; these were averaged ('49), since the femora, tibiae and humeri were fragmentary and it

TABLE 1

Mortality by age in populations of different epochs (Taken from Fusté, reprint without date, p. 328)

Origin	Period	n	Distribution by ages					Authors
			0–12	13–20	21–40	41–60	61–x	
			%	%	%	%	%	
Several	Lower paleolithic (H. neandertalensis)	20	40.0	15.0	40.0	5.0	0.0	Vallois ('37)[2]
Several	Upper paleolithic	102	24.5	9.8	53.9	11.8	0.0	Vallois ('37)[2]
Several	Mesolithic	65	30.8	6.2	58.5	3.0	1.5	Vallois ('37)[2]
Spanish Levant	Neo-eneolithic	101	24.7	14.8	41.6	17.8	1.0	Fusté ('52)
Anatolia	Chalcolithic and Copper Age	104	31.7	12.5	34.6	17.3	3.8	Several (Senyürek, '51)
Anatolia	Chalcolithic to 13th cent. B.C.	122	20.4	13.1	40.9	19.6	5.7	Senyürek, ('47)[3]
Aulnay-aux-Planches	Neolithic	28	0.0	7.1	64.3	25.0	3.6	Riquet ('43) and Fusté ('52)[1]
Austria	Bronze	273	6.9	17.2	39.9	28.6	7.3	Franz and Winkler ('36)[2]
Ancient Greeks	—	2,022	18.7	23.4	33.8	13.6	10.1	Several (Richardson, '33)[3]
Egyptians	Roman era	141	19.8	14.1	39.7	16.3	9.9	Pearson ('01–'02)[3]
Ancient Romans	—	8,065	38.1	19.9	30.0	7.1	4.6	MacDonell ('13)[3]
Spain and Lusitania	Roman era	1,996	9.4	16.4	38.8	19.9	15.2	MacDonell ('13)[3]
Africa	Roman era	10,697	9.9	9.4	28.4	19.6	32.4	MacDonell ('13)[3]
Lower Austria	1829	—	50.7	3.3	12.2	12.8	21.0	Franz and Winkler ('36)[2]
Lower Austria	1900	—	44.3	2.0	12.1	15.7	25.9	Franz and Winkler ('36)[2]
Lower Austria	1927	—	15.4	2.7	11.9	22.6	47.4	Franz and Winkler ('36)[2]
France	1896–1905	—	25.3	2.6	11.5	17.3	43.3	Vallois ('37)[2]
		n	0–14	15–19	20–39	40–59	61–x	
Spain	1948	299,178	21.8	2.3	11.8	16.3	47.7	Statistical Year Book, '50
Spain	1949	315,512	20.7	2.0	10.8	16.2	50.3	Statistical Year Book, '51
Spain	1950	300,112	19.7	1.9	10.1	15.9	52.4	Statistical Year Book, '52
Spain	1951	321,083	17.6	1.5	8.7	15.7	56.6	Statistical Year Book, '53

---

[1] Compilation of the Aulnay-aux-Planches series (Riquet, '43) and of the Dolmen des Bretons (Fusté, '52), of the same locality.

[2] The limit between the first two categories of ages is at 14 years.

[3] According to Senyürek, '51.

TABLE 2

	No. of cases	Min.	Max.	Av.
		cm	*cm*	*cm*
El Arbolillo	14	161.5	172.2	164.6
Ticoman	27	154.5	165.0	161.6
Tepexpan				166.6[1]

vas necessary to reconstruct them by comarison to homologous bones.

Farther on, Romero ('49, p. 112) estabished the comparison with the remains of l Arbolillo and Ticomán in the manner hown in table 2.

I find that the 164.6 cm average for El rbolillo is doubtless highly influenced by ne subject of 172.2 cm. Tepexpan, thereore, in comparison with males is much aller than the most ancient groups availble for comparison, although the value f 166.6 cm secured by measurement of he femora, is already 3.4 cm less than that iven ('49) as probable for the remains. f 27 individuals from Ticomán, all were maller than Tepexpan.

In a previous study (Genovés, '58, table V and p. 477) it was pointed out that in exican remains, and along general lines, pplying the formulae of Trotter and leser ('52, '58) for whites, values of tature reconstruction were obtained that re much higher if the tibia instead of the emur is used. In a small series (Coixtlauaca) I obtained differences of even 11 m between one and the other method for ales and up to 6 cm for females. Accordng to the preliminary results of another nvestigation (Genovés, unpublished) on ome Mexican prehispanic remains, I can ay that the tibiae, and above all, *the lnae and radii* give values that are higher, or either sex, than those obtained from he femora and that in general those values end to give statures which I have reason o consider as too large for those groups.

Furthermore, my reconstruction of the femora of Tepexpan would be slightly smaller than that of Romero. This author (p. 98) says that his variability in the different reconstructions is of 10 mm and gives the values of 434, 442, and 447 mm for the right, and only 447 mm for the left, taking later the average of 444 mm. I would be inclined toward a value of 439 mm, that gives for females (as I have reason to think that the Tepexpan "man" is probably a female), statures of 162 and 159.8 cm using Trotter and Gleser's ('52) formulas for Negro or White females respectively.

With reference to the tibiae and the right ulna and radius, I obtain the same values as Romero. The reconstruction of the humerus is too imperfect and therefore was not carried out here. Applying the formulas of Trotter and Gleser ('52) for White and Negro females to these bones, we would have the results shown in table 3.

I have good reason to think (Genovés, unpublished) that the stature taken from the femora is more valid, applying Trotter and Gleser's tables for White or Negro females ('52), and that the tibiae, radii and above all the ulnae give stature reconstructions that are completely disproportionate for mesoamericans, with which, in general lines, Trotter and Gleser are in agreement (personal communication, '59). That is, the leg and forearm are long in relation to the thigh, so that the formulae for Negro females (who possess these

TABLE 3

Bone		Stature	
		White	Negro
	mm	*cm*	*cm*
Femur	439	162.5	159.8
Tibia	378	171.2	165.2
Ulna	277	176.0	167.0
Radius	258	168.0	165.5

---

[1] Reconstruction solely on the basis of the femora.

characteristics) gives values for these bones that produce statures not too dissimilar from each other.[4] In other words, until stature reconstruction tables are elaborated for Mesoamerica, *it is not proper to average the results obtained with the different bones, since tibia, ulna and radius give values that are disproportionately high.* On the basis of this, plus the feminine character of the remains, I am inclined toward a 439 mm femur, to which would correspond an approximate stature of 160 cm (Trotter and Gleser, '52). It can, furthermore, be postulated in a preliminary way, that with respect to the long bones, those of the Tepexpan female fit the relative proportion patterns of the pre-Columbian remains. In this way, the Tepexpan specimen approaches more in stature what Romero proposed as an average for pre- or post-Columbians (de Terra, Romero and Stewart, '49, p. 102) and mentioned above.

Conclusion about stature

An estimation of the relative proportion of bone length in some mesoamerican specimens leads to the conclusion that averaging the reconstruction statures obtained through alien formulae for the different long bones is an unwarranted procedure for mesoamerican skeletons and that the femora provide in general lines the closest approximation to actual height. Based on this, on the feminine character of the specimen and on a new estimation of the length of the femur a stature of 1.60 is suggested for the Tepexpan remains.

Sex

On another occasion (Genovés, '54) I dealt with the problem of the diagnosis of the sex of fossil human remains of certain antiquity, arriving at the conclusion that there exists great disparity between the various authors that have examined the principal European finds and that therefore the sex designations are somewhat venturesome. I will not try now to adopt a definite or hasty position with regard to the sex of the Tepexpan remains; but I do believe that there are valid reasons for the opinion that the remains found at Tepexpan are probably those of a female. I transcribe the statement o Romero, ('49, p. 95) since it is brief:

Sex character

"From the beginning it appeared to m and to all others who studied the skeleta remains that they belonged to a male individual. The heavy muscle attachments a shown on the deltoid ridges of the humer the linea aspera of the femora and th popliteal lines of the tibiae are male characteristics. Unfortunately, we have onl one small fragment of the innominate, s I am unable to make use of the greate sciatic notch as a criterion for the mal sex. Neither could I use the size and shap of the pelvic cavity. The inclination o the femora is not sufficiently marked t raise doubts about the male."

"As for the skull, the brow ridges and th mastoid processes are of average development. The muscle attachment surfac in the nuchal region is not very marke whereas the superior occipital line is developed into the form of a true torus. Bu the shape of the forehead and the forame magnum[5] seem to indicate a male, whil the same may be said of the chin angl of the lower jaw, of which only the lef side is complete. I therefore agree wit Weidenreich's viewpoint as set forth in hi report: 'None of the bones is very robust on the contrary, they rather appear to b of a generally fine structure. Although thi suggests female sex, the strongly develope muscular tuberosities prove that the individual was a male.' (see Appendix B)."

"This sex determination is not supporte by any associations with material cultur objects or burial characteristics, such a have frequently aided us in Mexico in proper determination of sex characters i pre-Columbian burials."

It seems evident that the reasons give are rather weak. Sufficient female remain pertaining to cultures in which there i practically no differentiation of labor between the sexes are known, to state her that osseous eminences caused by muscular insertions can be, in these case quite appreciable in the feminine sex, so that we cannot apply the actual or pre-Columbian patterns, in general, to remains like those of Tepexpan. Furthermore, the muscular insertions (deltoidal, asperal line, popliteal line, etc.) are not really very strongly marked in the Tepexpan remains, and as Weidenreich indicates (de Terra, Romero and Stewart, '49, p. 124), "none of the bones is very robust."

---

[4] This is equally true, along general lines, fo males and for females.

[5] I am unaware of any actual sexual diffe ences—not even slightly appreciable ones—in th shape of this foramen.

Since there is nothing more than a very small fragment of os coxae and of sacrum, the determination as masculine based almost exclusively on the skull seems to us somewhat arbitrary, and in the discussion about the cranial characteristics (pp. 103–108) nothing is found that would favor clearly a masculine determination.

On our part, I have observed that the posterior root of the zygomatic process of the temporal, although appreciable, would be closer to a female sex assignation for the Tepexpan skull according to the findings of Keen ('50), who considers this characteristic to be perhaps that of the greatest value for the sexual diagnosis of the skull. The same author estimates that the degree of development of the supra-orbital crests, the occipital crest and the occipital lines are the best characteristics, together with that one already mentioned, and says (p. 72): "will always be valuable for sexing and presumably this *applies to the skulls of all racial groups*" (My italics). Although I cannot subscribe without reserve to the idea that these characteristics be applicable to the Tepexpan remains, I do wish to point out that of the 4 mentioned by Keen, all but one, the superior occipital line, favor a feminine diagnosis.

Unfortunately the tiny fragments of the clavicle and scapula are too reduced in size to deduce any information from them. However, it is a different matter with respect to the long bones. It should be stated first, however, that not knowing the degree of sexual dimorphism for Tepexpan one must be cautious in applying criteria obtained from other populations. In spite of this, it is true nonetheless that in the different human groups, it is practically always observed as a general sexual character, that there is a greater extention or size of the articulation surface in males than in females.

Dwight ('05), Tamagnini ('49) and Hrdlička ('52), among others, have put emphasis on the value of the articular surfaces, and recently Thieme ('57) and Thieme and Schull ('57) have demonstrated that the diameter of the head of the femur and the epicondilar width of the humerus have the highest value of "critical proportion"—"*t*"—among 8 other characters tested for sexual discrimination (Thieme, '57, p. 73, table I). In the Tepexpan remains, there are no measurable articular surfaces for femur, tibia or humerus, but there is an ulna and radius that are almost intact. Among approximately 100 masculine and feminine ulnae that are found in the laboratory of the National Museum of Anthropology, Mexico, only one (1.112(a), general classification Da-12) reaches the general size of Tepexpan's.

Now, Tepexpan's is less robust than those rather similar to it in size and only equal in robusticity to those that are quite smaller; the articular surface—sigmoid fossa—*is of the size of ulnae that are also much smaller.* The same thing is found to be true of the right radius of Tepexpan. Compared with 120 radii of diverse origins, kept at the Museum, *none* equals it in size, in spite of the fact that the superior and inferior articular surfaces in Tepexpan are *not greater* than those of the majority of these radii. That is, the articular surfaces of ulna and radius in the Tepexpan remains are proportionally small. What is more, the ulna, although somewhat deteriorated, does not present the transverse rugosity in the sigmoid cavity that Godycki ('57) describes as characteristic of masculine ulnae and that I have found useful for the sexual diagnosis in some mesoamerican ulnae.

Among the Tepexpan remains are also found two tali in a good state of preservation. I have compared them to the corresponding tali of masculine and feminine individuals whose femora and tibiae—masculine and feminine—give us the same stature as that calculated for Tepexpan. In all comparisons with masculine skeletons, the tali are larger than those of Tepexpan, whose tali I find to be practically equal to those of the female skeletons of similar stature with which they were compared.

I believe that all this data, although in no way conclusive, is much more in agreement with a designation of female sex to the Tepexpan remains.

Conclusion about sex

A reexamination of the skull, and of the articular facets of ulna and radius, of other characters of the long bones and of the tali leads to the conclusion that the specimen is most probably a female.

SUMMARY

The Tepexpan skeletal remains discovered in 1949 had been attributed to a male specimen of between 55–65 years of age and 1.70 m in stature.

The study of several characteristics of the skull and mainly of the long bones; the direct analysis of the bones and the comparison with the life duration of other specimens of general similar environment, and the inapplicability of averaging formulae for several long bones when reconstructing the stature of Mesoamerican populations, together with a new reconstruction of the femur, lead now to believe that Tepexpan is a female specimen of at most 30 years of age and of approximately only 1.60 m in stature.

NOTE

(a) While this paper was already in press, Dr. M. L. Moss came to Mexico, examined the Tepexpan material, read my paper and wrote a *Brief Communication* on "A Revaluation of the Dental Status and Chronological Age of the Tepexpan Remains," Amer. J. Phys. Anthrop., *N.S.*, *18:* 71–72, which coincides with my conclusion about the age of the specimen.

(b) At the advice of Dr. T. D. Stewart, Dr. H. Faulhaber, who has undertaken a study of the Tlatilco burials (1100–600 B.C.), and I were able to determine the chronological age of the specimens from this collection. Fifty-one admitted confident age diagnosis based on the symphyseal surface of the pubis.

Although indirectly, the distribution by age included here argues positively once more in favor of our conclusion about the age of the Tepexpan remains. Even more in general lines, suture closure age determination based on the traditional pattern also fails in the Tlatilco specimens, and extreme dental attrition, and premature dental loss was found, as in Tepexpan in many of the specimens.

Age range	N.
17–25	18
26–33	31
34–35	2
Total	51

ACKNOWLEDGMENTS

My gratitude to Professor J. Romero Head of the Department of Physical Anthropology, and to Dr. Eusebio Dávalos Hurtado, Director of the I.N.A.H. for permission to examine the specimens, and to Sr. Mario Pichardo del Barrio for assistance in the translation of the manuscript is herewith acknowledged.

LITERATURE CITED

Augier, M. 1932 Crâne et cerveau chez l vieillard. L'Anthrop., *42:* 315–322.

Cabot Briggs, L. 1958 Initiation á l'Anthropologie du Squelette. Imprimerie officiale, Alger 56 pp.

Cobb, M. W. 1955 The Age Incidence of Suture Closure. Am. J. Phys. Anthrop., *13:* 394 (Also in Anat. Rec., *121:* 277.)

Comas, J., and S. Genovés 1959 Paleoantropología y Evolución. Varia 1. Cuadernos de Instituto de Historia, serie antropógica, no. 6 U.N.A.M., Mexico, 47 pp.

De Terra, H., J. Romero and T. D. Stewart 194 Tepexpan Man. Viking Fund Publications in Anthropology, no. 11. New York, 160 pp.

Dwight, T. 1905 The size of the articular surfaces of the long bones as characteristic of sex Am. J. Anat., *4:* 19–31.

Fusté, M. (undated reprint) La duración d la vida en las poblaciones humanas del levant español durante el período neo-eneolítico. In Homenaje Póstumo al Dr. D. Francisco Pardill Vaquer. Universidad de Barcelona.

——— 1954 La duración de la vida en l población española desde la prehistoria hast nuestros días. In: Trabajos del Instituto "Bernardino de Sahagún" de Antropologia y Etno ogia, *14:* 81–104.

Genovés, S. 1954 The Problem of the Sex o Certain Fossil Hominids with Special Reference to the Neandertal Skeletons from Spy. J. R Anthrop. Inst., vol. 84, pp. 131–144.

——— 1958 Estudio de los restos óseos d Coixtlahuaca, Estado de Oaxaca, México. In Miscellanea Paul Rivet Octogenario Dicata vol. I, pp. 455–84.

——— (unpublished) Algunos aspectos relacionados con el cálculo de la talla en restos mexicanos.

enovés, S., and M. Messmacher 1959 Valor de los patrones tradicionales para la determinación de la edad por medio de las suturas en cráneos mexicanos (indígenas y mestizos). Cuadrenos del Instituto de Historia, Serie Antropológica no. 7. U.N.A.M., México, 53 pp.

odycki, M. 1957 Sur la certitude de détermination du sexe d'après le fémur, le cubitus et l'humérus. Bull. Mém. Soc. d'Anthrop. Paris. *8:* X ser., pp. 405–410.

oldestein, M. S. 1936 Changes in dimensions and form of the face and head with age. Am. J. Phys. Anthrop., *22:* 37–90.

ustafson, G. 1950 Age determination on teeth. J. Am. Dent. Assoc., *41:* 45–54.

ooton, E. A., and C. W. Dupertius 1951 Age changes and selective survival in Irish males. Studies in Physical Anthropology no. 2, Am. Assoc. Phys. Anthrop. and Wenner-Gren Foundation for Anthropological Research, New York.

Irdlička, A. 1952 Practical Anthropometry, 4th ed. by T. D. Stewart. The Wistar Institute of Anatomy and Biology, Philadelphia, 241 pp.

een, J. A. 1950 A study of the differences between male and female skulls. Am. J. Phys. Anthrop., N.S. *8:* 65–78.

asker, G. W. 1953 The age factor in bodily measurements of adult male and female Mexicans. Human Biol., *25:* 50–63.

ee, M. M. C., and G. W. Lasker 1958 The thickness of subcutaneous fat in elderly men. Am. J. Phys. Anthrop., *16:* 125–134.

Manouvrier, L. 1892 Determination de la taille d'après les grands os des membres. Rev. Men. l'École d'Anthrop., Ser. 2, *4:* 227–233.

McKern, T. W., and T. D. Stewart 1957 Skeletal Age Changes in Young American Males. Analyzed from the Standpoint of Age Identification. Quartermaster Research and Development Center, Environmental Protection Research Division, Natick, Massachusetts.

Sauter, M. R. 1947–48 and 1948–49 Quelques données sur la mortalité dans la population néolithique de la Suisse romande. Bull. Soc. Suiss. Anthrop. Ethnol., pp. 23–24.

Senyürek, M. S. 1947 A note on the duration of life on the ancient inhabitants of Anatolia. Am. J. Phys. Anthrop., *N.S.*, *5:* 55–56.

——— 1951 The longevity of the chalcolithic and Copper Age inhabitants of Anatolia. Belleten, *15:* 447–468.

Singer, R. 1953 Estimation of age from cranial suture closure. A report on its unreliability. J. Forensic Med., *1:* 52–59.

Stewart, T. D. 1957 Rate of development of vertebral hypertrophic arthritis and its utility in age estimation. Am. J. Phys. Anthrop., *N.S.*, *15:* 433.

Tamagnini, E., and D. Vieira de Campos 1949 Contribuiçoes para o Estudo da Antropologia Portuguesa, volume II Fascículo 1°, IV. *O Fémur Português,* pelo Dr. Eusébio Tamagnini e Daniel Saraiva Vieira de Campos. Universidad de Cornibra, Instituto de Antropologia, Cornibra 1949.

Testut, L. 1889 Recherches anthropologiques sur le esquelette quaternaire de Chancelade. Bull. Soc. Anthrop. Lyon, *8:* 1–124.

——— 1928 Traité d'Anatomie Humaine, 8th ed., by L. Latarjet. Paris.

Thieme, F. P. 1957 Sex in negro skeletons. J. Forensic Med., *4:* 72–81.

Thieme, F. P., and W. J. Schull 1957 Sex determination from the skeleton. Human Biol., *29:* 242–273.

Thompson Brooks, S. 1955 Skeletal age at death: The reliability of cranial and pubic age indicators. Am. J. Phys. Anthrop., *N.S.,13:* 567–597.

Todd, T. W., and D. W. Lyon, Jr. 1924–25 Endocranial suture closure: its progress and age relationship. Parts I, II, III, and IV. Ibid., *7:* 325–384; *8:* 23–40, 47–71, 149–168.

Todd, T. W. 1927 Skeletal records of mortality. The Scientific Monthly. *24:* 481–496.

Trotter, M., and G. C. Gleser 1951 The effect of ageing on stature. Am. J. Phys. Anthrop., *N.S.,9:* 311–324.

——— 1952 Estimation of stature from long bones of American Whites and Negroes. Ibid., *N.S.,10:* 463–514.

——— 1958 A re-evaluation of estimation of stature based on measurements of stature taken during life and of long bones after death. Seven figures. Ibid., *N.S.,16:* 79–134.

Vallois, H. V. 1937 La durée de la vie chez l'Homme fossile. L'Anthrop., *47:* 499–532.

——— 1941–46 Nouvelles recherches sur le squelette de Chancelade. L'Anthrop., *50:* 165–202.

Vandervael, F. 1952 Critères d'estimation de l'âge des squelettes entre 18 et 38 ans. S.A.S., pp. 25–26.

Weidenreich, F. 1949 Preliminary report on the anatomical character of the human skeleton from Tepexpan. In: de Terra H., J. Romero and T. D. Stewart, 1949, Tepexpan Man, Appendix B, pp. 123–124.

Variability in the Order of Ossification of the Bony Centers of the Hand and Wrist

STANLEY M. GARN AND CHRISTABEL G. ROHMANN
Fels Research Institute, Yellow Springs, Ohio

The order of appearance of the ossification centers of the hand and wrist has been described as regular and constant by several recent authors (Mackay, '57; Greulich and Pyle, '59). Although Pryor ('07) provided evidence over 50 years ago for individual differences in the ossification sequence of these bony nuclei, Mackay emphasized similarities in the mean ossification order between his Wadigo (East African) children, and the Chicago Laboratory School children in Flory's ('35) monograph. Greulich and Pyle in the latest edition of their *Atlas* have devoted considerable comment to ossification sequence, which they consider to be constant and the same for both sexes.

Although admitting the occurrence of individual differences in the ossification of hand-wrist centers, Greulich and Pyle minimize their incidence. They emphasize that "there is rather good agreement in the reported order of ossification . . . as observed in the various centers of child study in the United States" and observe that "the same order was reported by Sutow and his associates in their study of the skeletal development of children in Japan, and by Mackay in his similar study of children in the Kenya coastal area of East Africa" (Greulich and Pyle, '59, p. 24). Rejecting the sibling similarities in ossification pattern reported by Reynolds ('43) as much too infrequent, they attribute atypical ossification sequences to "childhood illnesses or other unfavorable environmental factors."

Actually, variability in the order of ossification cannot be determined from cross-sectional data alone, since different ossification sequences may be hidden in a single mean sequence. Nor can the extent of variability, or the proportion of children with aberrant ossification sequences be inferred from the mean ossification order. The only way the order of appearance of these postnatal centers of ossification can be determined is through the longitudinal analysis of complete serial hand-wrist radiographs. Furthermore, only by ascertaining individual ossification sequences is it possible to determine whether aberrant sequences are associated with delayed osseous maturation or heightened illness experience. The question of population similarities resolves itself into whether the incidence of different sequences is the same from group to group.

Accordingly, we have investigated variability in the order of appearance of 28 ossification centers of the hand and wrist longitudinally, using serial radiographs of a group of normal children followed from birth through completion of the sequence. The purpose of this paper is to report on the variability of individual ossification orders, the incidence of such variability and finally, to provide data on the relationship between hand-wrist ossification sequences and several developmental variables.

METHODS AND MATERIALS

The present study is based upon 2880 serial postero-anterior radiographs of the hand and wrist of 75 boys and 79 girls, all born in southwestern Ohio and all regular participants in the Fels Longitudinal Studies. The population sample considered was primarily rural and semi-urban in residence and of the lower-middle and middle-middle social class according to Warner's classification.

In making the analyses, twins, triplets and children with developmental defects were not included in the study. In addition, like-sexed siblings and children of Fels children were excluded to avoid loading the sample with particular lineages.[1] The 154 children represented in the present study were selected both to exclude family lines and to provide data on children with the most complete radiographic series.

The radiographs taken over a 21-year period were made at a three-foot tube-to-film distance using fast screen-type film with par-speed screens. Exposures varied from 9 to 15 milliampere-seconds and from 34 to 38 PKV depending on the age and part thickness. With use of the appropriate cones and other precautions, gonadal dosages were small, ranging down to 0.001 mr and less (cf. Garn and Shamir, '58). The radiographs themselves were taken at one, three, 6 and 9 months of age during the first year, and on birthdays and "half-birthdays" thereafter within extremely small tolerance limits (Garn and Shamir, '58, p. 16). Interpolation of ages was therefore neither necessary nor attempted.

The age at appearance of individual centers of ossification was determined for each child in the study. After computing the mean, by the usual method, median values were also determined. In addition to the means and medians, normalized T-scored values were computed using the McCall method and these normalized T-score values were used to compute both the mean T ($\bar{X}_T$) for all 28 centers of ossification and σ_T the measure of pattern variability. The mean T for each child, therefore, provided a numerical expression of overall earliness or lateness of hand-wrist development. σ_T, the measure of pattern variability, (Garn, '56) further provided an indication of the extent to which individual patterns of ossification differed from the expected pattern, ignoring the question of earliness or lateness.

Following the determinations of the mean and median orders from the mean and median ages of ossification, individual ossification sequences were next determined for the boys and girls in the upper 15% and lower 15% in pattern variability (σ_T). In recording the individual ossification orders for each of the boys and girls in these two series, centers that appeared at the same age, that is "bunched" centers, were arranged to follow the sex-speci median order for the present study. this way variability of ossification ord was minimized when there was no e dence for the exact sequence of a parti ular group of centers.

In addition to the individual ossificati order for all 28 centers determined f the boys and girls highest and lowest pattern variability, the ossification ord for 6 of the 7 carpal bones (excluding t Navicular) was ascertained for each the 154 children under consideratio Here the number of children following t "textbook" sequence and those deviati in various respects from the textbook s quence were separately enumerated.

Besides correlations involving the pa tern variability index (σ_T) and mean ($\bar{X}_T$) in order to determine whether the was a relationship between pattern va ability and developmental status, t health histories of the highest and lowe 15% of boys and girls in σ_T were reviewe by an independent observer (LL). He the health-history data were drawn fro the interval health history and the phy ical examination records for the childre concerned. Although there was a tendenc for more incidents of ill health to be r ported for the earlier-born Fels childre (corresponding to a period when physic examinations were conducted at more fr quent intervals), the distribution of yea at birth was the same in children hig and low in pattern variability.

Inasmuch as the prime data for th present study were obtained over a 2 year period and secular trends are know to exist for many variables such as statur and weight, tests for secular trend wer run using date of birth and the mea T ($\bar{X}_T$) for hand-wrist centers. Here th combined-sex correlations between date birth and mean T was 0.05 for the sampl of 154 children. Accordingly, it was fe that secular trends did not constitute a important source of error in the presen study. There was, moreover, no evidenc that in the present sample, pattern var

---

[1] Although like-sexed siblings were exclude the sample of 154 boys and girls did includ 32 siblings of unlike sex and 29 first or secon cousins.

TABLE 1

Order of appearance of ossification centers of the hand and wrist according to this study and to previous authors

Center	This study		Pyle and Sontag ('43)	Stuart in Nelson ('54)	Greulich and Pyle ('59)	
	Median	Mean			p. 16	p. 186
		Boys				
Capitate	1	1	1	1	1	1
Hamate	2	2	2	2	2	2
Distal radius	3	3	3	3	3	3
Proximal III	4	4	4	4	4	4
Proximal II	5	5	5	5	5	5
Distal I	6	*7*	*8*	*8*	*8*	*8*
Proximal IV	7	*6*	*6*	*6*	*6*	*6*
Metacarpal II	8	8	*7*	*7*	*7*	*7*
Metacarpal III	9	9	9	9	9	9
Metacarpal IV	10	*13*	*11*	*11*	*11*	10
Proximal V	11	*10*	*10*	*10*	*10*	11
Middle III	12	*11*	12	12	12	12
Middle IV	13	*12*	13	13	13	13
Metacarpal V	14	*15*	14	14	*15*	14
Middle II	15	*14*	15	15	*14*	15
Distal IV	16	*17*	*18*	16	*17*	*18*
Triquetral	17	*18*	*16*	*18*	*18*	*16*
Metacarpal I	18	*19*	*19*	*19*	*19*	*19*
Distal III	19	*16*	*17*	*17*	*16*	*17*
Proximal I	20	20	20	20	20	20
Distal II	21	21	21	21	*22*	*22*
Distal V	22	22	22	22	*21*	*21*
Middle V	23	23	23	23	23	23
Lunate	24	24	24	24	24	24
Navicular	25	*26*	25	25	25	*27*
Lesser multangular	26	*25*	*27*	*27*	*27*	26
Greater multangular	27	27	*26*	*26*	*26*	*25*
Distal ulna	28	28	28	28	28	28
		Girls				
Capitate	1	1	1	1	1	1
Hamate	2	2	2	2	2	2
Distal radius	3	*4*	*4*	3	3	3
Proximal III	4	*3*	*3*	4	4	4
Proximal II	5	5	5	5	5	5
Proximal IV	6	6	6	6	6	6
Distal I	7	7	7	7	7	*8*
Metacarpal II	8	8	8	8	8	*7*
Metacarpal III	9	9	9	9	9	9
Proximal V	10	10	10	10	10	*11*
Middle IV	11	11	11	11	*12*	*13*
Metacarpal IV	12	12	*13*	12	*13*	*10*
Middle III	13	13	*12*	13	*11*	*12*
Middle II	14	14	*15*	14	*15*	*15*
Metacarpal V	15	15	*14*	15	*14*	*14*
Distal III	16	16	*17*	16	16	*17*
Distal IV	17	17	*16*	17	17	*18*
Metacarpal I	18	18	18	18	18	*19*
Proximal I	19	19	19	19	19	*20*
Triquetral	20	20	20	20	20	*16*
Distal II	21	*23*	*23*	*22*	*23*	*22*
Middle V	22	*21*	*21*	*21*	*21*	*23*
Distal V	23	*22*	*22*	23	*22*	*21*
Lunate	24	24	24	24	24	24
Greater multangular	25	25	25	25	25	25
Navicular	26	26	26	*27*	*27*	*27*
Lesser multangular	27	27	27	*26*	*26*	*26*
Distal ulna	28	28	28	28	28	28

Tied values ranked in conformity with this study's median order, to minimize rank differences.

ability either increased or decreased over the span of years considered.[2]

FINDINGS

At the beginning of the study the mean ossification sequence was determined for boys and girls respectively, using the mean age at appearance for each of the 28 postnatal centers of ossification. In addition, the median sequence was computed for each sex, since many of the age-at-appearance distributions proved markedly skewed by the Pearsonian measure of skewness (Sk). The difference between the mean and median sequences as well as the extent of sexual dimorphism in ossification order is apparent in table 1.

Further, comparative data on ossification order were taken from the literature. These included the sequence listed by Greulich and Pyle on page 186 of their *Atlas*, (the only *sequence* actually given in the literature), and sequences computed from the mean values published by Pyle and Sontag ('43), Stuart and Stevenson ('54), and by Greulich and Pyle ('59) for Brush Foundation children. Other data like those of Sutow ('58) and Mackay ('52) and the earlier data of Flecker ('42) did not lend themselves readily to sequence determination and are, therefore, not included in the present comparison.

As is evident in table 1, the various sequences agree in the main, in that centers reported as early in appearance by one author are similarly reported as early by another. Rank-order correlations between various sequences are therefore high ($\rho > 0.9$), a fact that may be explained in part by the use of Pyle-Sontag data by Stuart and Stevenson, and overlapping between the Pyle-Sontag and present data. Nevertheless, there are differences between the sequences, differences as high as 26 using the summed rank-deviation technique (Σd). As shown in table 2, the mean and median sequences from the present study differ somewhat, greater or lesser differences are to be found in sequences derived from the published data, and even subsamples from the same population sample differ in mean sequence. Since data on 50, 100 and "all" boys and girls in the Brush Foundation Study (Greulich and Pyle, '59, pp. 16–17) differ in the sequences they provide, and since the Pyle-Sontag data and the present data yield somewhat different sequences for the Fels population, sampling errors are undoubtedly involved. Nevertheless, uniformity of sequence is far from certain and there is every indication of a true sex difference.

Following these excursions into massed-data sequences, attention was next directed to individual variations in ossification order. To do this the most variable and least variable boys and girls in ossification pattern (σ_T) were selected, using the upper 15% in pattern variability as indicative of the most variable children, and the lowest 15% as indicative of the least variable children. Individual ossification sequences were determined, after reviewing the radiographs for each child. By way of comparison *median sex-specific ossification sequences* for the present study were used, because of skewness and sexual dimorphism as previously noted.

As is shown in table 3, where individual ossification orders for the most variable boys and girls are tabulated, large deviations from the median order of appearance

TABLE 2

Summed rank differences (Σd) between different ossification sequences

Source of data	I	II	III	IV	V	VI
					Girls	
I This study, median	—	6	12	4	12	24
II This study, mean	18	—	6	6	10	26
III Pyle and Sontag ('43)	14	16	—	12	8	24
IV Stuart and Stevenson ('54)	12	14	4	—	8	22
V Greulich and Pyle (pp.16–17)	18	12	8	6	—	20
VI Greulich and Pyle (p. 186)	16	20	8	12	12	—
		Boys				

---

[2] Correlations between σ_T, the measure of pattern variability, and the date of birth were 0.0 for 154 boys and girls.

TABLE 3

Order of appearance of hand and wrist centers in most variable Fels boys and girls

Fels no.	σ_T	Order of appearance[1]																									
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
															Boys														
8	10.8	(1	2	3	6	17	24)	5	(4	7	8	9	11	16	18	19	21)	(10	12	13	14	15	20	22)	23	(26	27)	25	28
227	10.3	2	1	(4	5	7	17)	(3	6	8)	(11	12	15)	(9	10	13	14)	(18	20)	(16	19	24)	22	21	23	25	26	(27	28)
177	10.1	(1	2)	(4	5	6	7	17)	(3	8	9	10	11	12	13	18)	(14	15	20)	(16	19	23)	21	(22	27)	(24	25	26)	28
237	9.8	1	2	17	(4	5	6	7)	11	(3	8	9	12	13	23)	(10	14	15	24)	(16	19)	21	(20	22)	(18	26	27)	25	28
138	9.7	(1	2)	(5	8	9	12	13	15)	(3	6	17)	(4	7	19)	(10	11	14	16	18	21	22)	23	(20	24)	26	25	27	28
197	9.4	2	(1	3)	(4	5	7	8	9	10)	(6	11	14)	(12	13	15	18)	(16	19	20)	(21	22	23)	24	17	(25	26	27)	28
239	9.4	1	2	(4	5	7)	(6	12	13	15)	3	(8	10	11	16	19	21)	(9	23)	14	(17	18	20	22)	24	25	(26	27)	28
180	9.1	(1	2)	4	(5	6	7	8	12)	(3	9	10	11	13	14	15	19)	(16	18)	(17	20	21	22	23	24	27)	(25	26	28)
312	8.8	(1	2)	3	(4	5	6	8	9	10)	(7	11	14)	(18	20)	(15	16	17	19)	(12	13)	21	(22	24)	23	25	27	26	28
278	8.7	(1	2)	17	(3	5)	4	(7	8)	(9	10)	11	(6	12	13	15	18	20	23)	14	(16	19	21	24)	22	(25	27)	(26	28)
33	8.5	(1	2	3)	(4	5	6	7	8	9	11	12	13)	10	14	(15	16	17	18	20	23)	19	22	21	25	24	26	27	28
															Girls														
409	9.8	(1	2)	20	(3	7)	(4	5	6	8	16	17)	(9	10	11	12	13	14	15	18	19	21	22	23)	24	(25	26)	27	28
1	9.7	1	2	3	(5	7	8)	(4	6	9	12)	(10	15	18	20	24)	(11	13	14	16	17	19	21	26)	23	(22	25)	27	28
83	8.8	(1	2)	(4	5	6	11	13)	(3	7	14)	9	(8	10	12	15	16	17	18	21	22	23)	19	20	24	(25	27)	26	28
168	8.6	1	(2	4	5	6)	(3	9	10)	(7	8	11	12	13	14	15	16	17	18	19	22)	(21	23)	20	25	(24	26	27)	28
140	8.5	(1	2	20)	(3	24)	(7	8)	(4	5	6	9	12	26)	(10	15	18)	(11	13	14	16	17	19	23)	(21	22	25	27)	28
13	8.5	1	2	(3	20)	4	5	6	7	8	9	10	(11	15)	(12	13)	14	16	23	(17	18	19	21	22	24	25)	27	26	28
313	8.4	(1	2)	3	(4	8)	(5	6	7	9	12)	(10	11	13	15	16	18)	(14	19)	17	(20	21)	(22	23	27)	(24	25	26)	28
382	8.4	(1	2)	(4	5	6	7	10	11	13)	(14	16	17	22)	(3	8	9	15	18	19	21	23)	12	20	24	25	27	(26	28)
75	8.4	1	2	(4	5	6)	(7	8	9	10	11	13	16)	(12	14	15	17	23)	(3	18	19)	(21	22)	24	25	(20	27)	26	28
82	8.1	(1	2	3)	(4	5	7)	(6	8	9	10	11	12	13	14	18	19)	(15	16	17)	(21	22	23)	20	(25	26	28)	27	24
364	8.0	(1	2)	(3	4	5	6	7	17)	(8	9	11	13	14	16)	(10	12	15	18	19)	(21	22	23)	(20	24)	28	(26	27)	25
244	7.9	(1	2)	20	(3	7)	(4	6)	(5	8	9	10	12	13	14	15)	(11	16	17	18	19)	(21	22	23	24)	(25	26	27)	28

---

[1] The order of appearance of individual centers. The numbers given below correspond to the median order of appearance of centers as taken from table 1. Thus the order 1–2–20 for subject no. 409 refers to the sequence Capitate-Hamate-Triquetral, etc. Parentheses indicate "bunched" centers; see text, page 220.

exist. In extreme cases centers ordinarily appearing 17th or 24th in ossification order, appeared as early as 5th or 6th. In other cases, centers ordinarily earlier in rank order of ossification appeared late. Quantifying these deviations from the median order by the statistic Σd, that is the summed rank deviation, values of Σd as high as 100–106 were obtained. While certain ossification centers were particularly prone to deviation in ossification order, giving rise to large Σd values, all of the bony nuclei of the hand and wrist proved subject to deviations in order of appearance, and there was no systematic tendency for deviant centers to be either exclusively late or exclusively early in their departure from the median order.

Individual deviations from the median ossification order are further depicted in figures 1 and 2. In figure 1, a highly aberrant ossification order is shown, an order strikingly in contrast to the median ossification sequence. Other aberrant cases are graphed in figure 2, along with the least deviant boys and girls, who still do not fully conform to the median ossification order. Radiographic examples of aberrant ossification sequences are reproduced in the halftones (figs. 3 and 4) showing that unusually early appearance of particular carpal centers, unusually late ossification of certain of the carpal bones, or atypical orders involving metacarpal or digital epiphyses all contribute to such aberrant sequences as are detailed in table 3.

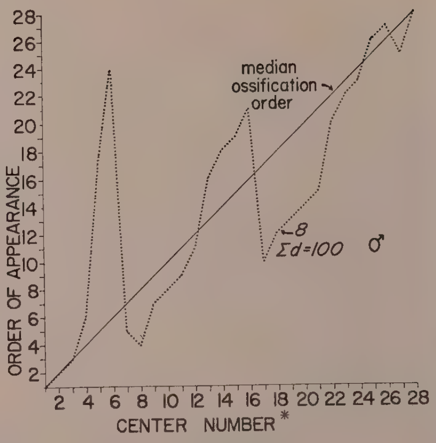


Fig. 1 Graphic representation of the most aberrant ossification sequence encountered among 75 boys in the series as compared to the median ossification order. In this subject, Fels no. 8, both positive and negative deviations from the median order contribute to the high rank deviation (Σd).

Since this analysis revealed a high proportion of aberrant ossification orders when all 28 ossification centers were considered, further attention was paid to the carpal centers (excluding the Navicular) since the carpals have been considered as regular and consistent in order of appearance. The actual ossification order for 6 carpal bones was ascertained individually for all 154 boys and girls, assigning the sequence given by Greulich and Pyle

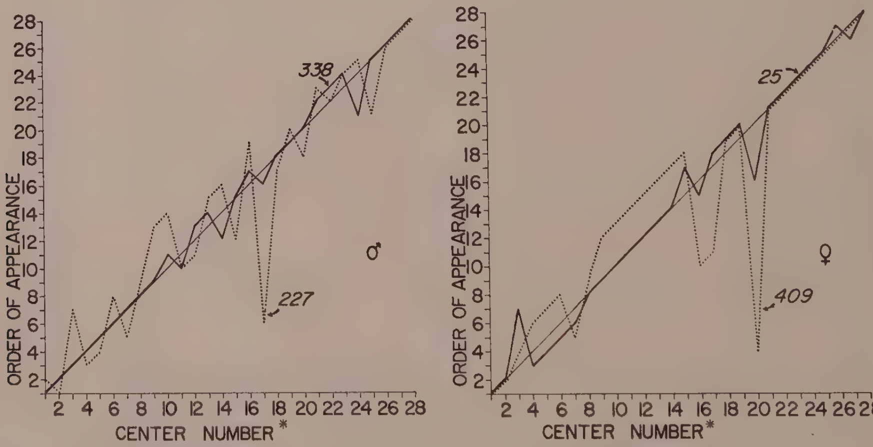


Fig. 2 Comparison of boys and girls with most deviant ossification orders (dotted lines) and children least deviant in ossification sequence (heavy lines). As shown, even the least deviant children in the study depart from the median order of sequence.

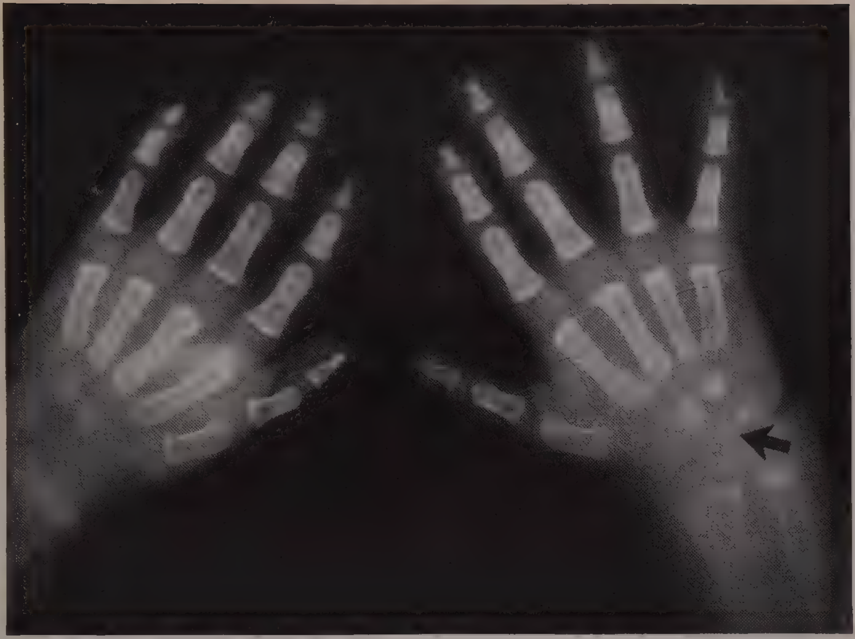


Fig. 3 Radiographs of the hand and wrist of subject no. 8 at 9 months of age showing unusually early appearance of the Triquetral and Lunate. The daughter of this subject, Fels no. 509, similarly evidenced early appearance of these two centers at 6 months of age, thus contributing to a comparably deviant ossification order.

whenever "bunching" of centers occurred. Nevertheless, the textbook sequence was not the only order, and in the boys it was not even the majority sequence. For 75 boys, only 49% followed the Capitate - Hamate - Triquetral - Lunate - Greater Multangular - Lesser Multangular order (table 4); 12 alternative sequences were observed for them. In the girls a larger proportion (61%) adhered to the sequence given; nevertheless the 79 girls were distributed among a total of 10 different sequences for these 6 carpal centers. In all, 15 sequences were found, instead of the one that had been suggested (cf. table 4).

Having considered variations in order of appearance of the 6 carpal centers, as well as variations in all 28 centers, attention was next directed to explanations for such variations. One possibility suggested by the literature was that abnormalities in ossification order might be associated with late osseous maturation. Another, apparently confirmed by studies on malnourished children, was that aberrant ossification orders were associated with illness, possibly to the extent that particular centers would be markedly delayed by episodes of ill health.

In order to test the first possibility, namely that pattern abnormality was associated with late hand-wrist development, the statistic σ_T (the measure of pattern variability) was correlated with the statistic $\bar{X}_T$, the index of ossification status. Since neither the sex-specific nor the combined-sex correlations between σ_T and $\bar{X}_T$ were significantly different from zero, the hypothesis in question could be rejected for the present population sample. Deviations in ossification order were not associated with late hand-wrist ossification.

The possibility that aberrant ossification sequences were associated with episodes of ill-health even in clinically-healthy children was explored using the complete health-history data available for each of the high-variability and low-variability boys and girls. To avoid bias, an independent observer reviewed the protocols without knowledge of the ossification status of the children involved. All recorded episodes were assigned to one of 4 noso-

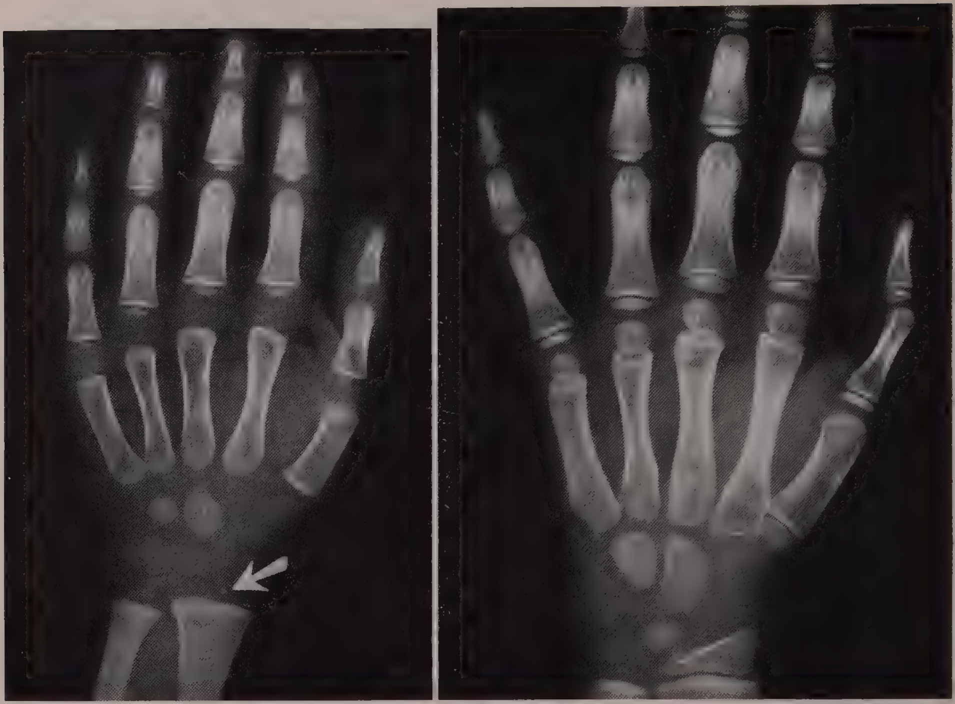


Fig. 4 Aberrant ossification sequence. Left, Fels subject no. 329 at 2.5 years of age showing the presence of the epiphyses of the proximal and middle segments of the digits and the absence of the epiphyses of the metacarpals. The arrow calls attention to the distal epiphyses of the radius which ordinarily precedes the epiphyses of the digits. Compare with Standards 8 and 9 in Greulich and Pyle ('59). Right, subject no. 197 showing delayed appearance of several carpal centers. Compare with Greulich and Pyle ('59) Standard 15 and Garn and Shamir ('58, fig. 8).

TABLE 4

Sequence of appearance of 6 carpal centers in 154 children

Sequence	1	2	3	4	5	6	Boys		Girls	
							No.	%	No.	%
A	Ca	Ha	Tr	Lu	GM	LM[1]	37	49	48	61
B	Ca	Ha	Tr	Lu	LM	GM	20	27	18	23
C	Ca	Ha	Tr	GM	Lu	LM	3	4	1	1
D	Ca	Ha	Tr	LM	Lu	GM	2	3	3	4
E	Ca	Ha	Tr	GM	LM	Lu	1	1	1	1
F	Ca	Ha	Tr	LM	GM	Lu	1	1	–	–
G	Ca	Ha	Lu	Tr	GM	LM	3	4	2	3
H	Ca	Ha	Lu	Tr	LM	GM	3	4	1	1
I	Ca	Ha	Lu	GM	Tr	LM	–	–	1	1
J	Ca	Ha	Lu	LM	Tr	GM	1	1	–	–
K	Ca	Ha	LM	Tr	Lu	GM	1	1	–	–
L	Ha	Ca	Tr	Lu	GM	LM	1	1	2	3
M	Ha	Ca	Tr	Lu	LM	GM	1	1	–	–
N	Ha	Ca	Lu	Tr	GM	LM	1	1	–	–
O	Ha	Ca	Lu	Tr	LM	GM	–	–	2	3

[1] Sequence (excluding the navicular) as described by Greulich and Pyle ('59, p. 24).

logical classifications: acute infectious, upper respiratory, gastro-intestinal and allergic, since major accidents during infancy and early childhood were not reported for the group in question.

In the girls, and for the first 7 years of life, there was no difference either in the number of episodes of ill-health reported, or in the type of illness noted. As shown in table 5, a total of 193 illness episodes were recorded for the girls high in ossification variability, as contrasted with 196 for the girls in the lowest 15% for pattern variability. In the boys, however, there was a distinct difference. The boys exhibiting aberrant ossification sequences, accounted for 205 episodes of upper-respiratory disease as contrasted with 133 in the boys low in ossification variability (cf. table 5).

However, careful review of individual illness data revealed that much of the difference in the boys was attributable to one lad (no. 227) with a reported total of 60 episodes of ill health (including 48 episodes of upper-respiratory distress) as contrasted with an average of 15 such episodes for other boys in the series over the same 7-year period. It was observed that his mother, a registered nurse still professionally active, tended to report far more illness data than was usual. For example, two of his siblings had close to 4 times as many reported incidents of ill health than the average of 4 other children matched-paired with these siblings on the basis of sex and date of birth.[3] Accordingly, we are inclined to discount the data on this particular child, and have therefore separately tabulated illness information for the remaining boys in his subgroup (see table 5). However, the data including subject no. 227 are also given. Relationships between illness—experience and ossification variability in boys thus remain equivocal, though no such relationship is demonstrable for the girls in the present study.

In summary, various massed-data ossification orders are not necessarily identical, though sampling error may account for some of the dissimilarities. Investigated on a longitudinal basis using serial data, individual deviations from the massed-data sequence are the rule and may be considerable indeed. Even the carpal centers do not neatly adhere to the textbook sequence. Divergences in hand-wrist ossification sequence are not related to delayed osseous maturation, and within the sample investigated there was no clear-cut evidence that atypical sequences of hand-wrist ossification were characteristic of children with stormier health histories.

---

[3] Two siblings of subject no. 227 (Fels nos. 179 and 343) were reported as having 45 and 58 episodes of ill health during the first 7 years of life. Pairing on the basis of sex and birth date for Fels subjects no. 182 and 185, 7 and 20 episodes of ill health were reported for the same time period, and for Fels subjects no. 336 and 354 a total of 21 and 12 such episodes were recorded.

TABLE 5

Comparative 7-year health histories of boys and girls highest and lowest in ossification variability

Group and sex	Acute infectious	Upper respiratory	Gastro-intestinal	Allergic
		Total no. of episodes		
11 Least variable boys	26	133	45	15
11 Most variable boys	34	205	64	9
10 Most variable boys[1]	31	157	54	9
12 Least variable girls	33	157	60	13
12 Most variable girls	25	149	48	10
		Average no. of episodes		
11 Least variable boys	2.4	12.2	4.1	1.3
11 Most variable boys	3.2	18.6	5.8	0.8
10 Most variable boys[1]	3.1	15.7	5.4	0.9
12 Least variable girls	2.7	13.1	5.0	1.1
12 Most variable girls	2.1	12.4	4.0	0.8

[1] Minus subject no. 227. For explanation see text.

DISCUSSION

It is apparent in the present study that, despite assurances in the literature, the order of appearance of the postnatal centers of ossification of the hand and wrist is not necessarily constant, either on an individual basis or a group basis.

Comparing various ossification "sequences" obtained by ranking mean ages at ossification for hand-wrist centers, agreement is by no means complete. Rank differences as great as 26 exist between ossification sequences given by various authors. While the discrepancies may stem from true differences between the various populations sampled, divergences between mean ossification sequences for successive subsamples of the Brush Foundation and Fels Institute populations suggest that sampling error is also involved. Under these circumstances much larger samples are obviously necessary to establish the true mean order of ossification for the 28 centers here considered.

That sex differences in ossification order exist now appears to be a certainty, with the Triquetral consistently later in the sequence in girls and the Greater Multangular-Lesser Multangular sequence also a feminine characteristic. However, skewness of many of the age-at-ossification curves indicates that the median ages at ossification would be more appropriate in establishing a typical sequence than the mean ages commonly used. But before urging sex-specific ossification orders based on median values, the limitations of such constructs should be noted. As Daniels showed in his "Average Man" (Daniels, '52) a compilation of averages (or medians) becomes less and less useful as the number of such averages increases, and that is precisely what we find in this study of ossification sequence.

On an individual basis, in clinically-healthy middle-class children from a relatively homogenous population sample, variability in ossification sequence proved the rule and not the rarity. The most deviant children exhibited summed rank differences of 100 and more, which is to say that each center differed from its median ranking by an average of 4. Even the least deviant boys and girls differed from the median order for the study. Contrary to expectation these deviations wer not due exclusively to late-appearing cen ters, nor were the carpals entirely respon sible for rank-order deviations. Metacarpal and digital epiphyses contribute their share to the aberrant ossificatio sequences. The Ulnar epiphysis in turn though highly variable in age at ossification, proved relatively consistent in oss fication order.[4]

Restricting the study to the order c appearance of 6 carpal centers previousl reported as "constant and the sam for both sexes" (Greulich and Pyle, '59 p. 24), neither constancy nor lack of sexual dimorphism were verified by our data Over half of the boys, and nearly 40% of the girls differed from the sequenc Capitate - Hamate - Triquetral - Lunate Greater Multangular - Lesser Multangula Of the 30-odd sequences mathematicall possible for these 6 centers, 15 were actually encountered, even though "bunched centers were arbitrarily assigned the tex book order.

One common explanation for aberran ossification order has been osseous retardation with the assumption that such developmental retardation favors patter variability. However, using the statisti σ_T as a measure of pattern variability, an the value of $\bar{X}_T$ as an indication of deve opmental status, correlations between th two were uniformly close to zero in bot sexes. A second explanation for atypica ossification orders, namely illness or ca oric deprivation, finds no certain suppo in our data. Granted that hand-wrist oss fication may be retarded in malnourishe children (Dreizen et al., '58) and tha "anamolous" centers may be more frequen in such children,[5] confirmation is no found for the proposition that variabilit is thus enhanced. Illness and caloric deficiency may favor pattern abnormalit but atypical ossification patterns are sti to be found in the absence of majo growth-retarding states.

---

[4] Dr. C. W. Asling informs us that the pos natal variability in appearance of metacarpal an phalangeal epiphyses in the Rhesus monkey substantial.

[5] O'Rahilly includes the reminder that such cen ters are merely calcified foci and not multip ossification centers (O'Rahilly, '57, p. 16).

At one point in our study, we were at a loss to reconcile the considerable variability in ossification order that our data revealed with the contrary opinions expressed in the literature. Various suggestions were entertained, including the possible uniqueness of the Fels sample. However, upon reviewing the literature from the earlier studies of Pryor ('06, '14, '25), through Flory ('35), Flecker ('42), Pyle and Sontag ('43), Todd ('37), Mackay ('52), Sutow ('53), Greulich and Pyle ('59) it was evident that with the exception of Pryor ('07) actual ossification sequences had not been analyzed. All other authors had been concerned with the mean or modal ages at ossification of individual centers and "sequences" (when given) merely recapitulated mean values. Notably, such massed data are ineffective in revealing individual sequences. In much the same way, statements concerning population similarities in ossification order have been made in the absence of individual ossification orders. As with tooth eruption sequences, we would not be surprised to find population differences in the frequency of different sequences of hand-wrist ossification (cf. Garn, Lewis and Shoemaker, '56).

This study, however, is not an attempt to emphasize variability in ossification in contrast to constancy. Without question, the Capitate and Hamate are always either first or second in ossification order. The Navicular, Greater and Lesser Multangulars (Trapezium and Trapezoid) and Distal Ulna are variously 25th, 26th, 27th and 28th in the ossification sequence. Rather, we are here interested in the quantification of variability in one aspect of what LeGros Clark has termed the "Total Morphological Pattern" and how this total morphological pattern differs from child to child.

Though we disagree with Greulich and Pyle in their opinions as to constancy and regularity in ossification sequence, these differences do not reflect upon the Greulich-Pyle skeletal-age method. If their detailed method of hand-age analysis is properly used, late-appearing centers do not influence the results, since they are not assigned skeletal-age values. However, such extreme variations in ossification order as are apparent in subjects no. 8, 140 and 239, greatly affect skeletal age estimates based on mere enumeration of centers, and for this reason we are skeptical of such methods even when Fels norms are used.

This investigation has deliberately avoided the genetical aspects of ossification order, intentionally excluding like-sex siblings, monozygotic twins and parents and children from the tabulations. We are aware that ossification orders are not precisely the same in single-egg twins and triplets, thus admitting the role of exogenous factors, including bilateral assymetrics (cf. Baer and Durkatz, '57). Nevertheless, we are impressed by the quite accidental discovery that subjects no. 8 and 509 (father and daughter) had identical highly-aberrant sequences, and recall the late-appearing syndrome (Garn and Shamir, '58, p. 45), Breitbach's analysis of Fels sibling similarities, and the work of Reynolds ('43) and Sontag and Reynolds ('44). It seems reasonable to suggest that, in a putatively healthy population, small deviations from the typical ossification order are the product of chance and environment (cf. Baer and Durkatz, '57) while large and aberrant deviations in ossification sequence are in such a group, largely gene-determined.

Further analysis of ossification orders using siblings, parent-child combinations and single-egg multiple births would be most desirable.

SUMMARY

1. The order of appearance of 28 postnatal ossification centers of the hand and wrist was investigated in 2880 serial longitudinal radiographs of 154 clinically-healthy Ohio-born children.

2. As compared with the median sequence for each sex, great variability in ossification order was observed, with rank deviations (Σd) as high as 106 in extreme cases. Even the least variable children exhibited notable divergences from the median sequence.

3. Although the order of appearance of the carpal centers has been reported as "constant and the same for both sexes," the majority of boys and 39% of the girls differed from the textbook sequence

for 6 carpal centers. A true sex difference in sequence was obvious for the Triquetral and Greater and Lesser Multangulars.

4. No relationship was found between pattern variability in ossification, as measured by the statistic (σ_T) and overall osseous maturity ($\bar{X}_T$).

5. Those children with deviant ossification orders were not characterized by more episodes of illness during the first 7 years of life.

6. The inadequacy of ossification orders based on mean or median values was demonstrated and the probability of true population differences in actual ossification orders was suggested.

ACKNOWLEDGMENTS

The authors acknowledge the assistance of Joan Adams Haskell and Dr. Lina Landkof in various parts of the present study. Figures 1 and 2 were drawn by Demarest L. Polacheck. Lois A. Conklin assisted in the manuscript preparation.

LITERATURE CITED

Baer, M. J., and J. Durkatz 1957 Bilateral asymmetry in skeletal maturation of the hand and wrist: a roentgenographic analysis. Am. J. Phys. Anthrop., *15:* 181–196.

Daniels, G. S. 1952 The "Average Man"? Tech. Note WCRD 53-7, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio.

Dreizen, S., R. M. Snodgrasse, H. Webb-Peploe and T. D. Spies 1958 The retarding effect of protracted undernutrition on the appearance of the postnatal ossification centers in the hand and wrist. Human Biol., *30:* 253–264.

Flecker, H. 1942 Time of appearance and fusion of ossification centers as observed by roentgenographic methods. Am. J. Roentgenol. Rad. Ther. *47:* 97–159.

Flory, C. D. 1935 Osseous development in the hand as an index of skeletal development. Monog. Soc. Res. Child Develop., 1 (3).

Garn, S. M. 1955 Relative fat patterning: an individual characteristic. Human Biol., *27:* 75–89.

Garn, S. M., A. B. Lewis and W. D. Shoemaker 1956 The sequence of calcification of the mandibular molar and premolar teeth. J. Dent. Res., *35:* 555–561.

Garn, S. M., and C. G. Rohmann 1959 Communalities of the ossification centers of the hand and wrist. Am. J. Phys. Anthrop., *17:* 319–323.

Garn, S. M., and Z. Shamir 1958 Methods fo Research in Human Growth. C. C Thomas Springfield, Illinois.

Greulich, W. W., and S. I. Pyle 1950, 195 Radiographic Atlas of Skeletal Developmen of the Hand and Wrist. Stanford Universit Press, Stanford, Cal.

MacKay, D. H. 1952 Skeletal maturation i the hand; a study of development in Eas African children. Roy. Soc. Trop. Med. Hyg *46:* 135–150.

O'Rahilly, R. 1956 Developmental deviation in the carpus and the tarsus. Clin. Orthopaed *10:* 9–18.

Pryor, J. W. 1906 Ossification of the Epiphyse of the Hand. Transylvania Press, Lexington

——— 1907 The hereditary nature of varia tion in the ossification of bones. Anat. Rec., 1 84–88.

——— 1936 Ossification as additional ev dence in differentiating identicals and frate nals in multiple births. Am. J. Anat., *59:* 409 423.

Pyle, I., and L. W. Sontag 1943 Variability i onset of ossification in epiphyses and shor bones of the extremities. Am. J. Roentgeno Rad. Ther., *49:* 795–798.

Reynolds, E. L. 1943 Degree of kinship an pattern of ossification. Am. J. Phys. Anthrop N. S. *1:* 405–416.

Reynolds, E. L., and G. Schoen 1947 Growt patterns of identical triplets from 8 to 18 years Child Develop., *18:* 130–151.

Snodgrasse, R. M., S. Dreizen, C. Currie, G. S Parker and T. D. Spies 1955 The associatio between anomalous ossification centers in th hand and wrist, nutritional status and rate o skeletal maturation in children five to fourtee years of age. Am. J. Roentgenol. Rad. The Nuclear Med., *74:* 1037–1048.

Snodgrasse, R. M., S. Dreizen, G. S. Parker an T. D. Spies 1955 Serial sequential develop ment of anomalous metacarpal and phalangea ossification centers in the human hand Growth, *19:* 307–322.

Sontag, L. W., and J. Lipford 1943 The effec of illness and other factors on the appearanc pattern of skeletal epiphyses. J. Pediat., 23 391–409.

Stuart, H. C., and S. S. Stevenson 1954 Car and evaluation of well children. In: Textboo of Pediatrics, 6th ed., W. E. Nelson, ed. W. B Saunders, Philadelphia, pp. 10–66.

Sutow, W. W. 1958 Skeletal maturation i healthy Japanese children, 6 to 19 years of age Hiroshima J. Med. Sci., *2:* 181–191.

Todd, T. W. 1937 Atlas of Skeletal Maturatio (Hand). C. V. Mosby, St. Louis.

Washburn, A. H. 1957 The appraisal of healt during growth from birth to adolescense. In ed Brennemann's Practice of Pediatrics, I. Mc Quarrie, W. F. Pryor Co., Hagerstown, chap. 8

WILLIAM W. GREULICH

Viking Fund Medalist
for 1959

WILLIAM W. GREULICH

Viking Fund Medalist for 1959

Dr. William W. Greulich, president of the American Association of Physical Anthropologists, is one of the most original, far-sighted, and versatile workers on human growth. Never content simply to describe, he has attacked biometrically, biochemically, and radiographically those basic processes which underlie our humanity and individuality. These processes are the genetic, hormonal, and environmental determination of ovulation, fertilization, and implantation of the human egg and the timing of each critical stage in later growth. Perhaps because penetration into the causal nexus of our development demands cautious statement as well as daring ideas, Dr. Greulich is an extraordinarily modest man.

For the anthropologist Dr. Greulich's key achievements are, first of all, the organizing and directing of the Adolescence Study Unit at Yale during the 1930's. This was the first truly interdisciplinary analysis of human growth and development and it included people from anatomy, physiology, biochemistry, pediatrics, psychology, and sociology all working actively in their own departments of the medical school. Second, through the good fortune of succeeding T. Wingate Todd as director of the Brush Foundation in Cleveland in the early 1940's, Greulich completed Todd's program of setting up optimal growth standards, largely on the skeleton, of critical usefulness to pediatrics, nutrition, etc., and of great interest for human genetics. Third, on leave from Stanford University in the late 1940's as consultant to the Committee on Atomic Casualties, Greulich had the opportunity to extend his study of growth and development to non-white children. He studied children in Guam and in Japan, both those who survived the atom-bombing of Hiroshima and Nagasaki and controls from surrounding regions, and American-born Japanese children, all in comparison with American children and with each other. Finally he has done radiological studies of newborn Africans in Uganda, and of individuality of the hand skeleton in youth to adulthood.

At the outset of his career, in Denver and Stanford in the late 1920's Greulich worked out the incidence of human multiple births in various populations and the role of heredity in their causation: in other words the genetic and ecologic background of extra fertility of one sort. His demonstration that deepening in shape of the bony birth canal in American and other women reflects improved nutrition and better economic status is a classic study, partly because he showed how pelvic growth timing relates to the rest of the skeleton and to specific stages of puberal and adolescent development in girls and in boys. I am reminded that two key squeezes in human evolution are fertility in relation to life span and the relation between the increasingly huge human brain and the pelvis through which this must pass at birth.

In the functional physiology of conception and pregnancy Dr. Greulich pioneered in establishing the basal temperature change which accompanies ovulation and the detailed stages and development of the corpus luteum on the ovary. He worked further on the interaction between pituitary and steroid hormones mediating the precise physical changes of puberty and adolescence.

Professor Greulich is head of the Stanford University department of anatomy, where he is a creative teacher. We usually undervalue teaching. This point deserves stress because from working with students one learns caution in judging performance, optimism in seeing ideas develop, respect for the rights of others, and a love of truth and of hard work.

It is precisely these qualities — cautious optimism, hard work, respect for others, and love of truth—which ensured the success of what Dr. Greulich calls his extracurricular activity: his years in Germany from 1952–54 as science advisor to the U.S. High Commissioner, Dr. James Bryant Conant (and as chairman of the U.S. Educational Committee to the Federal Republic of Germany). This work, he notes, gave him a great deal of satisfaction both for what was accomplished officially and for the chance to visit the universities of West Germany and Austria and to know well many of their teachers. This was pioneering work, in which Greulich set the precedent, and which he carried out so well that the Foreign Service last year reinstituted the Science Advisor program. Such work is the breath of life to international amity and vital to American science.

What sort of man has achieved this stature?

Dr. Greulich was born in Columbus, Ohio, in 1899. His great grandfather was among that group of hungry Germans who emigrated in 1848 and whose contribution to our midwest was great, since their hunger was as much for culture as for bread. Greulich's childhood was not care free. After his parents died he worked at night and in summers (as a clerk, as a pool hall rack boy, and as a flagpole painter) in order to finish high school. Then he enlisted in the Army and spent some time in Veterans' hospitals before attending Kenyon College where he got a bachelor of philosophy degree in 1926. Meeting these challenges was not only a matter of guts and patience but also of one further quality, a true sense of humor. Out of this adversity he drew a far stronger philosophy than most college students have; it was typical of his clarity of purpose that he married, before finishing college, a most capable woman who was a Red Cross administrator and became his assistant in much of his later research. They settled in Denver, Colorado, where he taught and studied biology at Regis College and at the University of Colorado, and where his sons were born. Here he did his research on the ecological, demographic, and genetic background of twinning, influenced in part by the ecologist Francis Ramaley and Harvard pediatrician Alfred Washburn, wh had just started the Child Research Council for the Study of Human Growth.

In 1931 the genetically minded anatomist, C. H. Danforth, induced him t come to Stanford, where he got his Ph.D in 1934. Danforth and A. W. Meyer further aroused his interest in endocrin mediation of growth processes. Such wa the multiple background which stimulate Greulich's many-sided research as well a his skill in cooperative enterprises. Dr Greulich is an author of two books o adolescence, a series of books on skeleta maturation, and many original articles He is a member of the Society for Researc in Child Development, Sigma Xi, AAAS AAPA, American Association of Anatomists, and editor of scientific journals.

In Dr. Greulich we honor a man a notable for his modesty as for his achievements, a man as successful in carrying ou interdisciplinary research as in plannin it, a man whose counsel our governmen sought for practical reflections of his research, and a man who has raised a brilliant family with the same enthusiasm an scope seen in his lecturing throughout thi country and abroad. We honor him a investigator, teacher, and sound adviso And specifically the American Associatio of Physical Anthropologists cite him a recipient of the Viking Fund Medal an Award in Physical Anthropology "in recognition of his efforts to perfect and mak available accurate studies in the U.S Guam, and Japan on the effect of environment and race on the growth and development of the individual."

Dr. Paul Fejos, as President of th Wenner-Gren Foundation for Anthropological Research, presented at the fourteent annual dinner at the Plaza Hotel on Marc 4, 1960, the Viking Fund Medals an Awards for 1959 to the winners respectively chosen by the American Anthropological Association, the Society for America Archeology and the American Associatio of Physical Anthropologists. The vice president of this last group read the citaton for Dr. W. W. Greulich, as medalis and president of the Association.

J. Lawrence Angel, *Vice-Presiden*
American Association of Physical Anthropologist

BRIEF COMMUNICATION

Genetic Analysis in Russian Immigrants[1]

PTC SENSITIVITY, FINGER PRINTS, COLOR VISION, HAND CLASPING, AND ARM FOLDING

A. FREIRE-MAIA, N. FREIRE-MAIA AND A. QUELCE-SALGADO
Laboratório de Genética Humana, Faculdade de Filosofia,
Universidade do Paraná, Curitiba, Pr.
Brasil

Migration is one of the factors which modify gene frequencies in populations. It is interesting to study immigrants, not only to know the frequencies of genetic traits in their ethnic group, but also to evaluate the differential genetic contributions they are carrying to their new country. With this double purpose, we analyzed a number of unrelated, almost exclusively adult Russian immigrants, who had arrived in 1958 at the State of Paraná, Brazil. They belong to a large religious sect (*Raskolniki* or Old Believers) which dissented from the reforms introduced into the Russian Orthodox Church in 1654. Known as conservatives, ascetics and abstemious, they form an isolate which maintains old practices and customs. The oldest members of the group analyzed were born in different parts of USSR, the middle aged and younger ones were born in China (where they migrated to after the Communist Revolution) and the infants were born in Hong Kong (where they stayed for a while before coming to Brazil).

The purpose of this note is to present preliminary information obtained among these immigrants. More data will be obtained and published later.

Taste thresholds for Phenylthiourea

Weak solutions of the chemical Phenylthiourea (PTC) is tasted by some persons (tasters), but not by others (non-tasters). The incapacity to taste the substance, or the capacity to taste it only in strong solutions, is considered to be conditioned by a main autosomic recessive gene. Different populations may show different frequencies of non-tasters, and, on this subject, a number of papers have been published. Regarding people from USSR, previous data showed frequencies of non-tasters around 20% and 40% (Boyd and Boyd, '37). The technique used in testing these subjects was not very precise however. In our analysis, the technique developed by Harris and Kalmus ('49) was used, but the solutions were prepared with distilled water instead of boiled tap water.

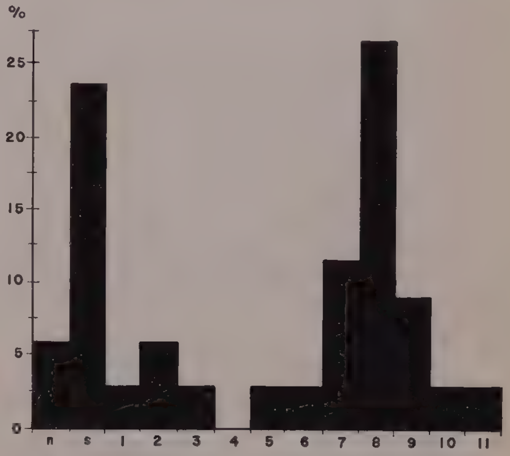


Fig. 1 Taste thresholds for PTC in Russian females.

The results are given in figures 1, 2, 3, and tables 1 and 2. The antimode between

---

[1] This work has been supported by grants from the Research Council of the University of Paraná, the National Research Council of Brazil, and the Rockefeller Foundation.

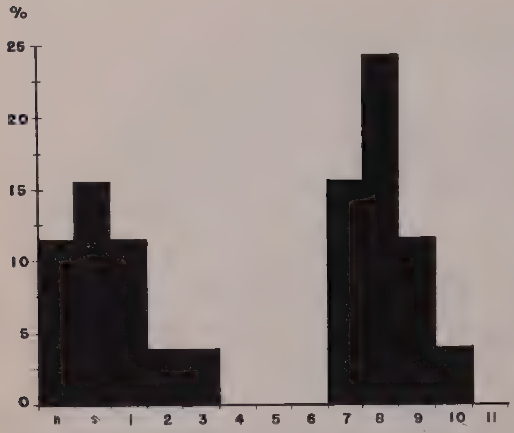


Fig. 2 Taste thresholds for PTC in Russian males.

tasters and non-tasters is clearly seen as situated between solutions 3 and 4 in both sub-samples of males and females or in the total sample. Regarding sex, no statistically significant difference was found between the frequencies of tasters and non-tasters, as well as between the mean taste thresholds (table 1). The pooled data (males plus females) show one of the highest frequency of non-tasters thus far observed (43%).

Comparing the frequencies of non-tasters in our data to those obtained by Boyd and Boyd ('37) in Zagorsk (37%) and Kharkov (42%) one finds that the differences are statistically not significant ($\chi^2 =$ 1.03, $P > 0.30$; and $\chi^2 = 1.17$, $P > 0.20$, respectively). An opposite situation is found however when one compares our data to those obtained in Tiflis (23% non-tasters) by the same authors ($\chi^2 = 11.16$; $P <$ 0.01).

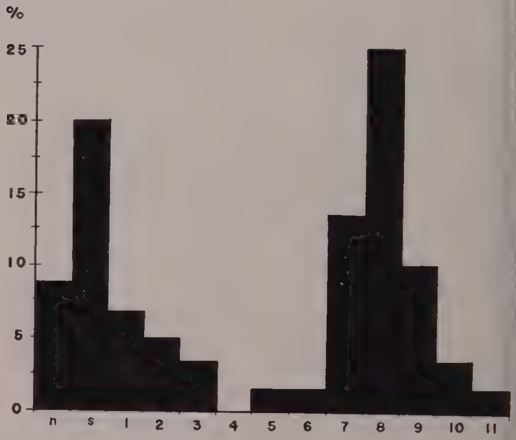


Fig. 3 Taste thresholds for PTC in Russians (males plus females).

TABLE 1

Distributions of the PTC taste thresholds among males and females

	Females	Males	Total
PTC sensitivity			
n	2	3	5
s	8	4	12
1	1	3	4
2	2	1	3
3	1	1	2
4	–	–	–
5	1	–	1
6	1	–	1
7	4	4	8
8	9	6	15
9	3	3	6
10	1	1	2
11	1	–	1
Total	34	26	60
Non-tasters			
Per cent[1]	41.18	46.15	43.33
Gene freq.[2]	0.6417	0.6794	0.6583
Mean threshold	4.91 ± 0.66	4.65 ± 0.76	4.80 ± 0.50

n = no one solution was tasted.
s = saturated solution.

[1] Statistical analysis: $\chi^2 = 0.15$, P = 70%.

[2] Statistical analysis: t = 0.26, P = 80%.

TABLE 2

Mean taste thresholds for tasters and non-tasters among Russians (immigrants to the State of Paraná) and Caucasians from Curitiba, the State capital

	Tasters	Non-tasters	Total
Russians	8.00 ± 0.20	0.62 ± 0.19	4.80 ± 0.50
Curitiba	8.49 ± 0.13	1.54 ± 0.28	6.67 ± 0.35
Statistical analysis	t = 2.06 $P < 0.05$	t = 2.75 $P < 0.01$	t = 3.09 $P < 0.01$

It would be interesting to compare our Russian data to those obtained in a sample of Caucasians from Curitiba, capital of the State of Paraná (cf. Freire-Maia and Quelce-Salgado, '60). An analysis between the frequencies of non-tasters among the Russian group and the sample from Curitiba (26.09%; N = 92) revealed that the differences are statistically significant ($\chi^2 = 4.89$; $P < 0.05$). The low mean taste threshold of the Russians (4.80 ± 0.50), which is significantly different from that of Curitiba (6.67 ± 0.35), could perhaps, at first sight, be considered as due to their high frequency of non-tasters (43.33%), when compared to that frequency in the sample from Curitiba (26.09%). Table 2 shows however that the low mean taste threshold of the Russians is not due exclusively to their high frequency of non-tasters, since the mean thresholds among tasters and non-tasters in the Russian sample are also statistically lower than those in the Curitiba sample.

TABLE 3

Frequencies (%) of the finger print types

	Males	Females	Total
Arches	2.72	0.59	1.70
Loops	65.22	58.58	62.04
Radial	7.61	2.96	5.38
Ulnar	57.61	55.62	56.66
Whorls	32.06	40.83	36.26

Finger prints

Data obtained in 19 males and 17 females regarding the frequencies of finger print types (table 3) and mean ridge counts (table 4) are presented. The main findings may be summarized as follows: (1) A low frequency of arches, an intermediate frequency of whorls, and a high frequency of loops (ulnar loops being more frequent than radial ones) have been found in both sexes. (2) Females show a higher frequency of whorls and a lower frequency of arches than males, but the differences are not significant (χ^2 equal to 0.78 and 2.67, respectively). (3) Compared to the left hand fingers, right hand fingers show higher mean ridge counts in 4 cases in males and in three cases in females, as well as in the mean of the 5 fingers both for males and females. (4) Right finger I in males and females shows the highest mean ridge counts of all the fingers. (5) In the R + L data, fingers I and IV present the highest mean ridge counts in males and in females. (6) The mean total ridge count is 137.68 ± 10.57 for males and 156.88 ± 8.72 for females (the difference is not statistically significant, since t = 1.38).

Findings 1, 3, 4, and 5 are in the same direction as those generally available in the literature, but findings 2 and 6 are in the opposite direction (as a matter of fact,

TABLE 4

Mean ridge counts in the right (R) and left (L) hand fingers

Fingers	Males			Females		
	R	L	R + L	R	L	R + L
I	21.05	16.00	18.53	19.29	15.76	17.53
II	11.63	10.89	11.27	13.59	13.56	13.58
III	11.58	11.29	11.44	13.41	13.76	13.59
IV	15.74	18.00	16.81	18.06	18.41	18.24
V	13.05	12.83	12.95	16.06	15.76	15.91
I–V	14.62	13.81	14.22	16.08	15.48	15.78

finding 6 is probably a consequence of 2) (cf. Cummins and Midlo, '43). Other comparisons of mean ridge counts do not always show identical results to those generally found in the literature, but the differences are too small to suggest, in so small a sample, any biological significance.

Color vision

Using the twelfth revised edition of the Ishihara tables, tests were made with 25 males and 38 females. All the females proved to be normal, but two males were protanopes and two were deuteranopes, giving a frequency of color blinds equal to 16% (8% for each type). Due to the small sample, this apparently high frequency does not differ significantly from the most common frequencies detected in other ethnic groups, as the error is about 7%.

Hand clasping

When one clasps the hands, two alternative positions are possible: the fingers of the right hand are put over the fingers of the left hand (type R), or vice-versa (type L). The trait is somewhat under the control of parental influence, which probably has a genetic nature (Freire-Maia et al., '58). Statistically significant differences between the frequencies of the two types in a number of ethnic groups were also found.

In our present data (table 5), no sexual difference was found ($\chi^2 = 0.52$; $P > 0.30$). The pooled data (males plus females) are statistically not different from those obtained in each one of the ethnic groups already studied. This situation is due to the small Russian sample, whose composition agrees, however, more closely with the data from the Caucasian group.

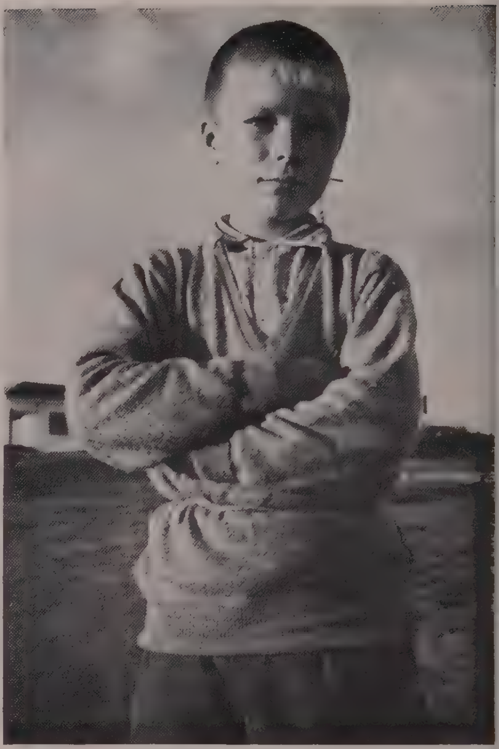


Fig. 4 A Russian boy shows the R type of arm folding (the right arm occupies the uppermost position).

Arm folding

Arm folding presents two alternative positions: R (for right; see fig. 4) and L (for left), according to the arm occupying the uppermost position. Unpublished data obtained by the present authors suggest the action of pre-natal factors (probably genetic in nature) on the presence of the trait. No simple Mendelian mechanism could however explain the findings.

Unpublished population data, obtained among Caucasians, Mulattoes, Negroes, Mongolians and Indians, showed that R individuals are always the minority (with

TABLE 5

Hand clasping in Russian immigrants (the sexual differences are statistically not significant)

Individuals	R type	L type	Total
Females	18 (52.94%)	16 (47.06%)	34
Males	15 (62.50%)	9 (37.50%)	24
Total	33 (56.90%)	25 (43.10%)	58

TABLE 6

Arm folding in Russian immigrants (the sexual differences are statistically not significant)

Individuals	R type	L type	Total
Females	31 (93.94%)	2 (6.06%)	33
Males	21 (87.50%)	3 (12.50%)	24
Total	52 (91.23%)	5 (8.77%)	57

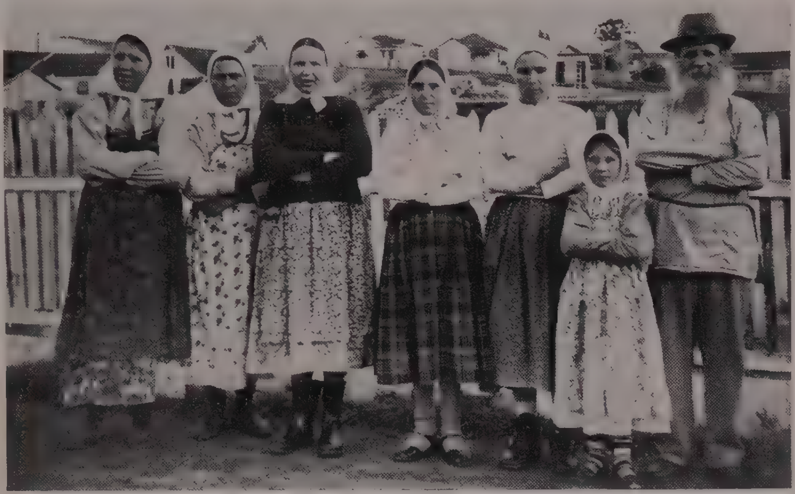


Fig. 5 A group of Russian immigrants, taken at random, show the extremely high frequency of the R type of arm folding.

frequencies generally around 40%) in all the samples analyzed, excluding one small sample (60% R; N = 25) of Guaraní Indians. Our present data show however a quite different situation, with a too high frequency (91%) of R individuals (see table 6 and fig. 5). A comparison between these data and the total data obtained in the ethnic groups cited above (41.53% R; N = 7633) shows that the differences are highly significant ($\chi^2 = 57.41$; $P < 0.01$).

SUMMARY

Data obtained in a sample of Russian immigrants to Brazil are presented. The main findings are as follows:

1. The frequency of non-tasters to PTC (43%) is one of the highest so far found. The mean taste threshold is significantly lower than that obtained in a sample of Caucasian subjects from Brazil.
2. The analysis of finger prints did not disclose any striking difference from what is generally known in other ethnic groups.
3. Regarding color vision, all the 38 females analyzed proved to be normal. Among the 25 males tested, two were protanopes and two were deuteranopes.
4. The frequency of the R type of hand clasping was 57% , which roughly agrees with previous data obtained in different ethnic groups.
5. An extremely high frequency of the R type of arm folding (91%) has been found. This is a completely new situation, since all the data obtained in other ethnic groups showed frequencies generally around 40% .

ACKNOWLEDGMENTS

The authors express their indebtedness to Dr. Arthur Iorio, for his valuable help in the analysis of the finger prints, and to Dr. Nicola Martini, Dr. Eduardo Olesko, Dr. Nardy Müller da Costa, Mr. Luiz Mazeneck, Dr. Arlindo Brume, and Dr. Antonio Gaidus, who made possible this research.

Appreciation is also expressed to Prof. C. Pavan, Prof. O. Frota-Pessoa and the staff of the Dept. of General Biology (University of São Paulo), where the analysis of part of these data had its origin.

LITERATURE CITED

Boyd, W. C., and L. G. Boyd 1937 Sexual and racial variations in ability to taste Phenyl-Thio-Carbamide, with some data on the inheritance. Ann. Hum. Genet., *8:* 46–51.

Cummins, H., and C. Midlo 1943 Finger Prints Palms and Soles. The Blakiston Co., Philadelphia.

Freire-Maia, A., and A. Quelce-Salgado 196 Taste sensitivity to PTC in samples from three Brazilian populations. Ann. Hum. Genet., *24* 97–102.

Freire-Maia, N., A. Quelce-Salgado and A. FreireMaia 1958 Hand clasping in different ethni groups. Human Biol., *30:* 281–291.

Harris, H., and H. Kalmus 1949 The measurement of taste sensitivity to Phenylthiourea (P.T.C.). Ann. Hum. Genet., *15:* 24–31.

The Dentition of the First Agriculturists (Jarmo, Iraq)[1]

ALBERT A. DAHLBERG
Zoller Memorial Dental Clinic and Department of Anthropology, University of Chicago, Chicago, Illinois

Many characteristics of the dentition serve to distinguish individuals or even populations from each other and can be utilized in forensic, anthropologic and dental studies. Odontologists have become increasingly aware of the existence and the significance of differences between dentitions (Moorrees, '57; Pedersen, '49; Dahlberg, '51).

Various types of dentitions have existed throughout man's history. Some were seemingly essential for survival in various environments, others were not. Consequently, it is of interest to know the morphology and conditions of the teeth in the individuals who were associated with the great steps in man's advance from the primitive to the modern.

One of the most significant of these progressive moves took place in the transition from the nomadic hunting and collecting existence to the more sedentary agricultural village life involving the cultivation of crops and the domestication of animals. This change did not develop necessarily as the culmination of the efforts of one precocious group, but probably resulted from the gradually evolving comprehension and exchange of ideas in the environment which offered the proper moisture, soil, temperatures and conditions suited to such activities (Braidwood, '58). There were circumstances in some geographical areas under which this could not and did not happen. Related to our present civilizations it was in the lands of the fertile crescent of Mesopotamia, in the wake of the withdrawal of the last glaciation, that these favorable backgrounds invited man with his increased capacities to forge ahead in what Childe ('52) and others have called the agricultural revolution.

In 1951 and 1955 Robert Braidwood ('53, '59) and his associates engaged in successful expeditions in Iraq to locate some of these earliest villages. The site which they exploited is known as Jarmo and is located in the Kurdish foothills of north-central Iraq. The village dates back to 6750 B.C. ± 500 years by Carbon 14 determinations (Braidwood, '58; Braidwood and Howe, '60).

MATERIALS

In addition to the implements, pottery, dwelling evidences and other archaeological articles that were found, some of the bones and teeth of the Jarmoites themselves were unearthed. Preservation had not been the best, therefore specimens were fragmentary. In total, parts of 7 individuals were collected including 96 permanent teeth and 30 deciduous ones with varying amounts of alveolar bone still attached to the teeth.

The bones were very friable and had to be cleaned and prepared with the utmost care. The teeth had a normal outward appearance. However, because they were leached without mineral replacement such as ordinarily occurs in the fossilization process, they were very easily broken, such as a piece of chalk under pressure (fig. 1). This was an advantage for inspecting the interiors of the teeth to study pulp chamber size and other details. Several specimens of each type of tooth were available. The material was not sufficient to permit a definitive statement on the teeth, but it does give some intimation of the dentition of these people.

---

[1] This study was supported in part by the National Institute of Dental Research grant D-165.

(such as the role of emotional factors in measurements of skin resistance); and greater awareness of what goes into a good study will aid them in gaining the confidence of foundations, colleagues, and administrators. The larger number of students of human growth, and of those engaged in comparable studies of other aspects of human biology, will value this book chiefly as an introduction to some of the published work in this area of knowledge, and for the critical apparatus to aid in its appreciation. The general use of non-technical language to explain technical concepts is commendable. References which may puzzle the uninitiated reader, for instance one to "the familiar Gompertz equation," are notable for their rarity. The illustrations augment and elucidate the text. By setting standards as high as or higher than those of the best-conducted growth studies, such as that of the Fels Institute (to which one-quarter of the references cited refer), this work will serve to upgrade studies of human growth from a rather lowly place in anthropological and pediatric research to the more central position demanded by the theoretical and practical importance of problems of growth. The research activities of the authors themselves and of those stimulated by a reading of this book should hasten its own obsolescence and soon make necessary a greatly expanded second edition.

Gabriel Ward Lasker
Wayne State University
Detroit, Michigan

THE DEATH of ADAM. By John C. Greene. Iowa State University Press, Ames, Iowa. 1959. 388 pp.

The Death of Adam is an intellectual history of the emergence of the idea of evolution. The book is unusually well written and lavishly illustrated; two features which make for pleasant as well as informative reading. The author is Professor of History at Iowa State University, and in 1959 this volume was awarded the Centennial citation and prize as the Most Outstanding Manuscript by an Iowa State faculty member.

The objective of *The Death of Adam* is "to trace the leading ideas which entered into Darwin's great synthesis." To accomplish this goal the author begins in the latter part of the seventeenth century, a time in which theological explanations for naturalistic observations are not only common, but in fact, the rule of the day. In the first four chapters Greene sets the stage for an ideological conflict between the "stability and orderly" view of nature and the "chance and change" view which ultimately triumphs. The conflict is told with a keen awareness and with continual reminders of the social and ideological context in which it is fought. Essentially the story is but one segment of the history of the conflict between science and theology; indeed a most important segment since its end marks the beginning of science's successful emergence from this conflict.

The remaining chapters might well be regarded as a history of physical anthropology in its early phase. These chapters deal with the implications of the larger ideological struggle on an understanding of man's place in nature, cultural evolution, race, and Darwinism and its critics. Indeed the list of subjects covered reads like an outline of an introductory course in physical anthropology.

In general, the information presented in this book will not be new to most professional anthropologists. The book is, however, well documented, well organized, and thoroughly readable. These attributes make it particularly valuable as a reference book for interested students.

Jack Kelso
University of Colorado

The Dentition of the First Agriculturists (Jarmo, Iraq)[1]

ALBERT A. DAHLBERG
Zoller Memorial Dental Clinic and Department of Anthropology, University of Chicago, Chicago, Illinois

Many characteristics of the dentition serve to distinguish individuals or even populations from each other and can be utilized in forensic, anthropologic and dental studies. Odontologists have become increasingly aware of the existence and the significance of differences between dentitions (Moorrees, '57; Pedersen, '49; Dahlberg, '51).

Various types of dentitions have existed throughout man's history. Some were seemingly essential for survival in various environments, others were not. Consequently, it is of interest to know the morphology and conditions of the teeth in the individuals who were associated with the great steps in man's advance from the primitive to the modern.

One of the most significant of these progressive moves took place in the transition from the nomadic hunting and collecting existence to the more sedentary agricultural village life involving the cultivation of crops and the domestication of animals. This change did not develop necessarily as the culmination of the efforts of one precocious group, but probably resulted from the gradually evolving comprehension and exchange of ideas in the environment which offered the proper moisture, soil, temperatures and conditions suited to such activities (Braidwood, '58). There were circumstances in some geographical areas under which this could not and did not happen. Related to our present civilizations it was in the lands of the fertile crescent of Mesopotamia, in the wake of the withdrawal of the last glaciation, that these favorable backgrounds invited man with his increased capacities to forge ahead in what Childe ('52) and others have called the agricultural revolution.

In 1951 and 1955 Robert Braidwood ('53, '59) and his associates engaged in successful expeditions in Iraq to locate some of these earliest villages. The site which they exploited is known as Jarmo and is located in the Kurdish foothills of north-central Iraq. The village dates back to 6750 B.C. ± 500 years by Carbon 14 determinations (Braidwood, '58; Braidwood and Howe, '60).

MATERIALS

In addition to the implements, pottery, dwelling evidences and other archaeological articles that were found, some of the bones and teeth of the Jarmoites themselves were unearthed. Preservation had not been the best, therefore specimens were fragmentary. In total, parts of 7 individuals were collected including 96 permanent teeth and 30 deciduous ones with varying amounts of alveolar bone still attached to the teeth.

The bones were very friable and had to be cleaned and prepared with the utmost care. The teeth had a normal outward appearance. However, because they were leached without mineral replacement such as ordinarily occurs in the fossilization process, they were very easily broken, such as a piece of chalk under pressure (fig. 1). This was an advantage for inspecting the interiors of the teeth to study pulp chamber size and other details. Several specimens of each type of tooth were available. The material was not sufficient to permit a definitive statement on the teeth, but it does give some intimation of the dentition of these people.

---

[1] This study was supported in part by the National Institute of Dental Research grant D-165.

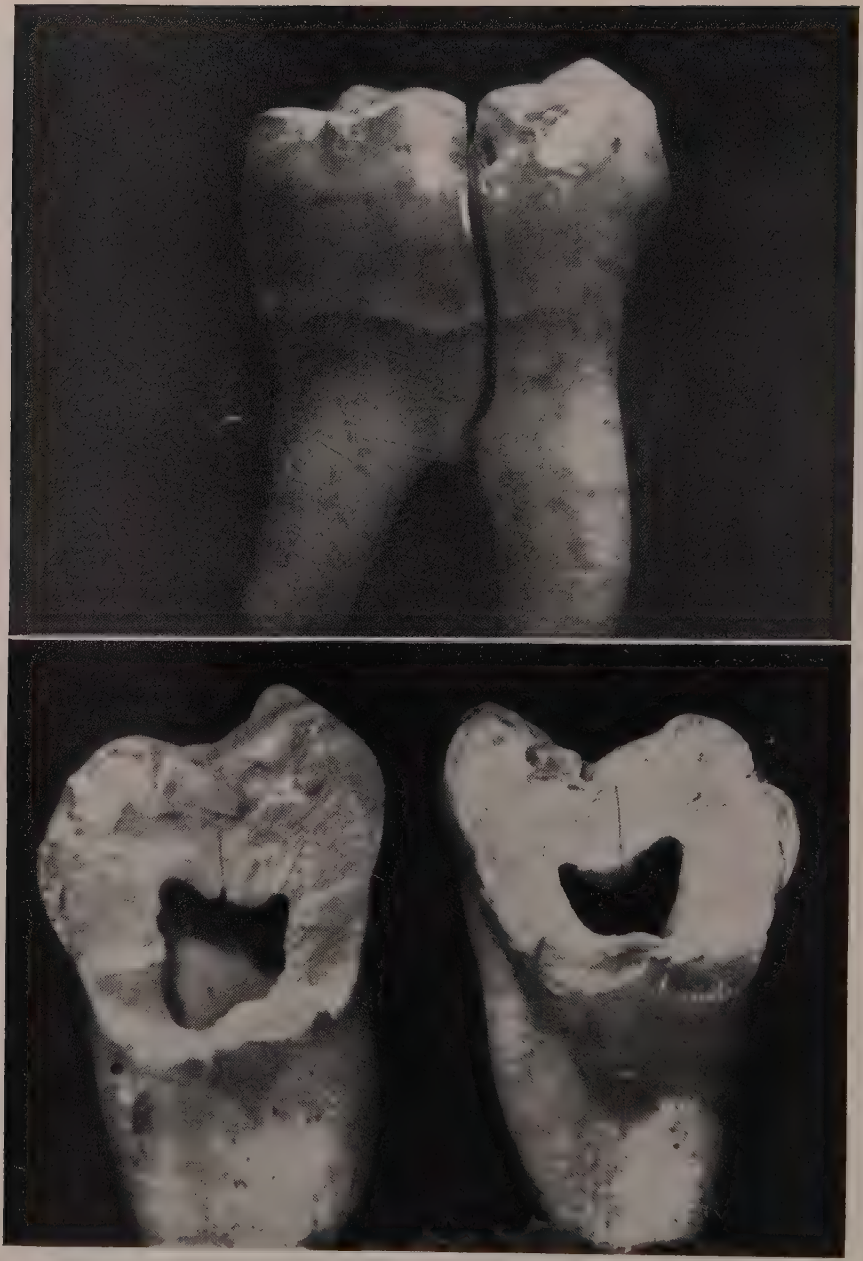


Fig. 1 Fractured permanent mandibular right first molar of Jarmoite. The size of the pulp chamber is easily seen in this section.

The excellent straight alignment and absence of malpositions in the teeth is suggestive of a relative homogeneity of the group. The dental arches were generally narrow in form with a high palate.

General description of the teeth

Whatever induced the Jarmoites to leave the caves for the more exposed areas of farmlands they must also have had

TABLE 1

Mesiodistal crown diameters (mm) of permanent maxillary teeth of Jarmoites, Natufians and Chicago White Males

	Jarmoites		Natufians[1]			Chicago White Males[2]		
	N	M	N	M	SE_M	N	M	SE_M
I_1	2	8.8	9	8.92	0.18	104	8.77	0.06
I_2	4	6.7	8	6.67	0.15	92	6.78	0.06
C	5	8.3	10	7.72	0.13	76	7.87	0.06
Pm_1	2	7.5	13	7.01	0.08	74	6.90	0.06
Pm_2	3	7.8	15	6.85	0.09	71	6.73	0.06
M_1	5	10.8	14	10.87	0.18	79	10.54	0.06
M_2	5	10.2	11	10.52	0.16	55	10.04	0.01
M_3	1	8.4	8	9.34	0.26	9	8.87	0.36

[1,2] From unpublished data of tooth measurements, right side of the dental arches only. The Jarmoites and the Natufians are both of mixed sexes.

TABLE 2

Mesiodistal crown diameters (mm) of permanent mandibular teeth of Jarmoites, Natufians and Chicago White Males

	Jarmoites		Natufians[1]			Chicago White Males[2]		
	N	M	N	M	SE_M	N	M	SE_M
I	3	5.3	10	5.37	0.12	104	5.38	0.04
I_2	3	6.0	13	5.95	0.16	105	5.99	0.05
C	4	7.1	13	7.03	0.11	96	6.88	0.05
Pm_1	3	8.0	16	7.06	0.13	90	6.97	0.06
Pm_2	3	8.3	14	7.18	0.09	70	7.06	0.05
M_1	6	11.4	16	11.52	0.12	80	10.97	0.08
M_2	6	11.0	16	11.05	0.11	53	10.78	0.13
M_3	2	11.1	14	10.90	0.12	7	10.20	0.59

TABLE 3

Labiolingual and buccolingual crown diameters (mm) of permanent maxillary teeth of Jarmoites, Natufians and Chicago White Males

	Jarmoites		Natufians[1]			Chicago White Males[2]		
	N	M	N	M	SE_M	N	M	SE_M
I_1	2	6.6	8	7.26	0.14	98	7.11	0.06
I_2	4	6.0	8	6.82	0.17	83	6.32	0.06
C	5	8.4	9	8.61	0.17	68	8.44	0.09
Pm_1	2	9.5	13	9.44	0.14	84	9.15	0.07
Pm_2	2	9.8	15	9.53	0.13	83	9.38	0.07
M_1	5	11.4	14	12.3	0.09	90	11.32	0.08
M_2	5	11.4	11	12.14	0.12	71	11.28	0.14
M_3	1	10.7	8	11.3	0.24	12	10.85	0.24

TABLE 4

Labiolingual and buccolingual crown diameters (mm) of permanent mandibular teeth of Jarmoites, Natufians and Chicago White Males

	Jarmoites		Natufians[1]			Chicago White Males[2]		
	N	M	N	M	SE_M	N	M	SE_M
I_1	3	5.8	10	6.21	0.16	102	5.94	0.05
I_2	3	6.1	13	6.61	0.12	103	6.25	0.05
C	4	7.7	13	7.91	0.12	90	7.53	0.07
Pm_1	3	7.4	16	7.82	0.11	88	7.64	0.06
Pm_2	3	8.6	14	8.24	0.40	79	8.20	0.10
M_1	6	10.5	16	10.76	0.07	90	10.58	0.06
M_2	6	10.1	16	10.62	0.08	62	10.50	0.08
M_3	2	10.8	13	10.40	0.15	12	10.23	0.24

capacities and means for protection. Certainly this was not forthcoming from their dentition which was small to medium in size with many elements reduced in prominence and efficiency. These teeth, seen in the limited number available are small compared to most fossils and even to most of the hominid dentitions of the present time. Tables 1 to 4 contain the tooth crown measurements of a modern white male population and a middle-east group from Mesolithic Palestine for comparison with those of the Jarmoites. The small number of teeth from Jarmo does not permit detailed statistical comparison, but it is to be noted that the means in many instances deviate less than three times the standard error from the means of the other two groups. The teeth have no Mongoloid features. With respect to size and

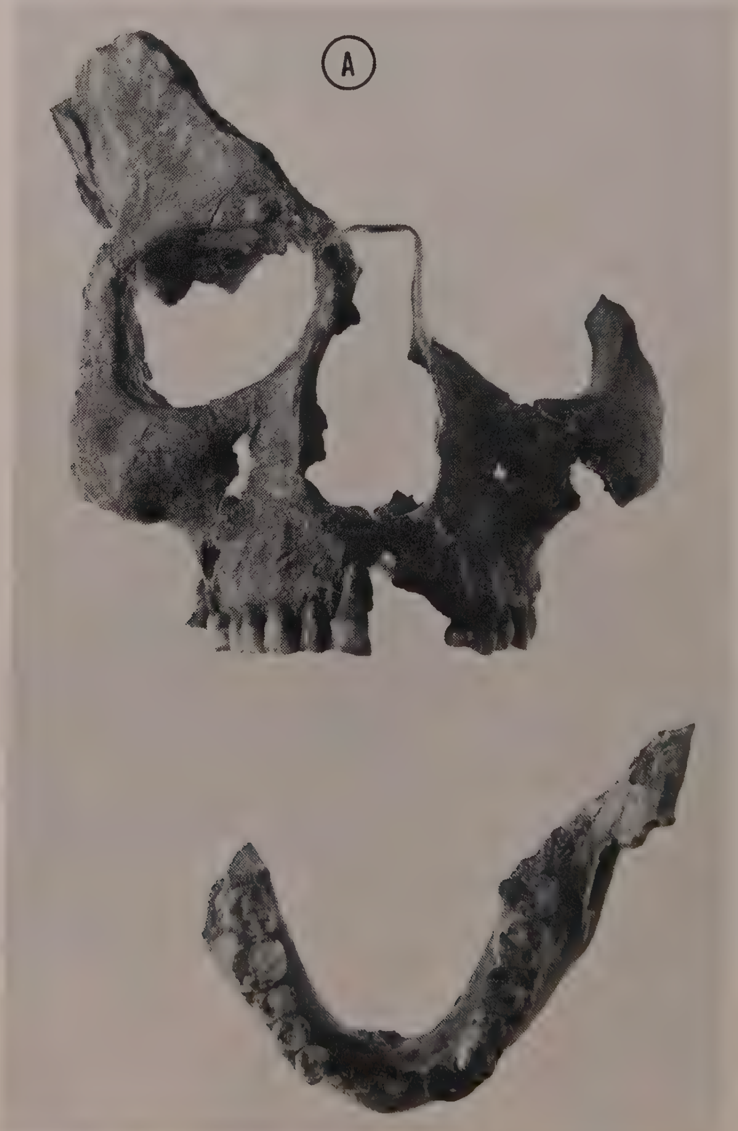


Fig. 2A Front view of facial bones of Jarmoite and occlusal view of the corresponding mandible.

conservativeness in form they resemble the general Mediterranean pattern. The newly erupted teeth of the young presented a wrinkled occlusal surface which might have had a temporary advantage in mastication, but was not a prolonged aid to the individual. These wrinkles normally wear off within a few years after the teeth have become functional. Four of the 7 individuals available for study lived to advanced age as evidenced by the extent and character of the wear and the condition of their teeth.

The only prominent feature about the face was the pointed chin. This is apparent from parts of the 4 mandibles that

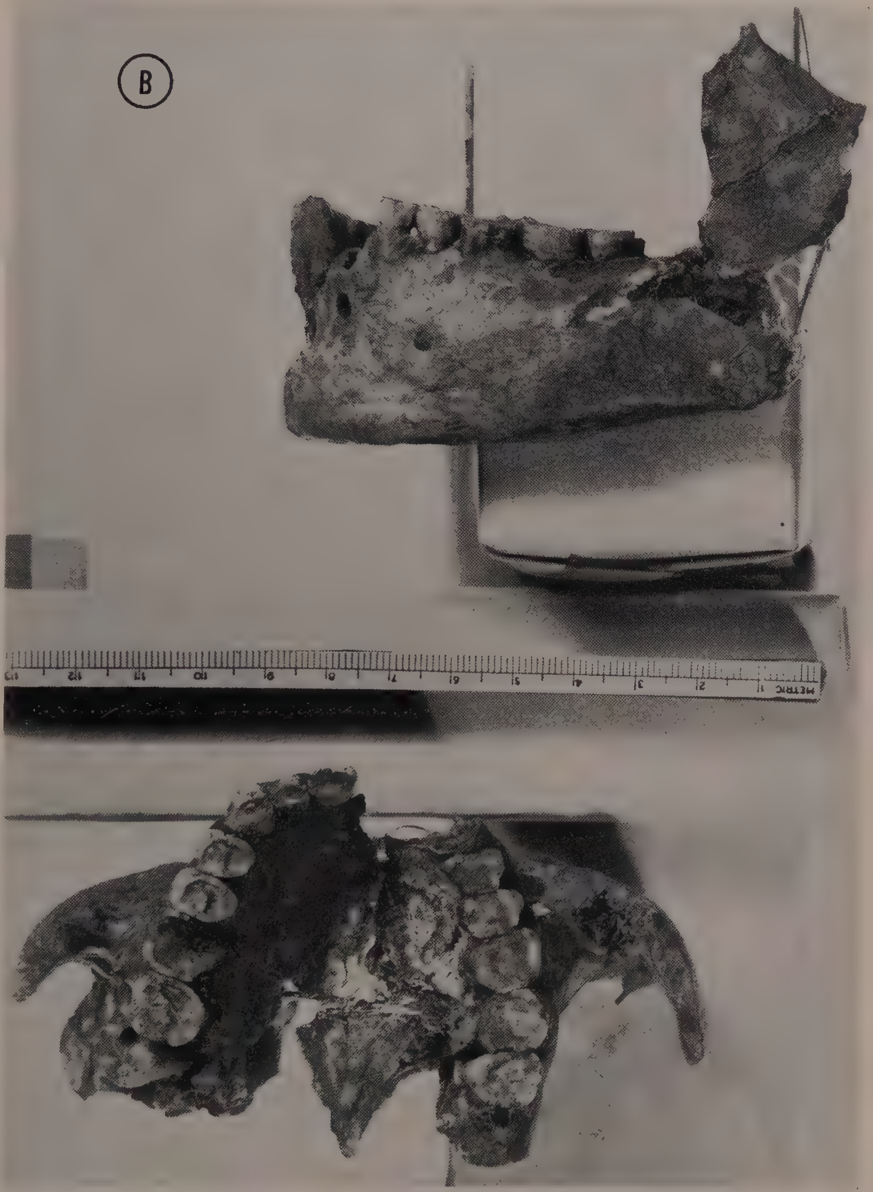


Fig. 2B Lateral view of mandible and occlusal view of maxilla of Jarmoite.

were preserved. The jaws were not prognathic. The angles of the jaws were acute. J. L. Angel ('57), in describing one of the specimens states that, "the face is therefore relatively narrow though not really high (figs. 2A and 2B). The chewing plane may have been more sloping than usual as in Iranian skulls and the nonflaring jaw angles were probably not obtuse. The general impression is a face showing Iranian as well as Mediterranean traits, with possible similarity to the Lower Egyptian Dineroid type of Mediterranean as in the ninth dynasty sediment series of Woo and Morant."

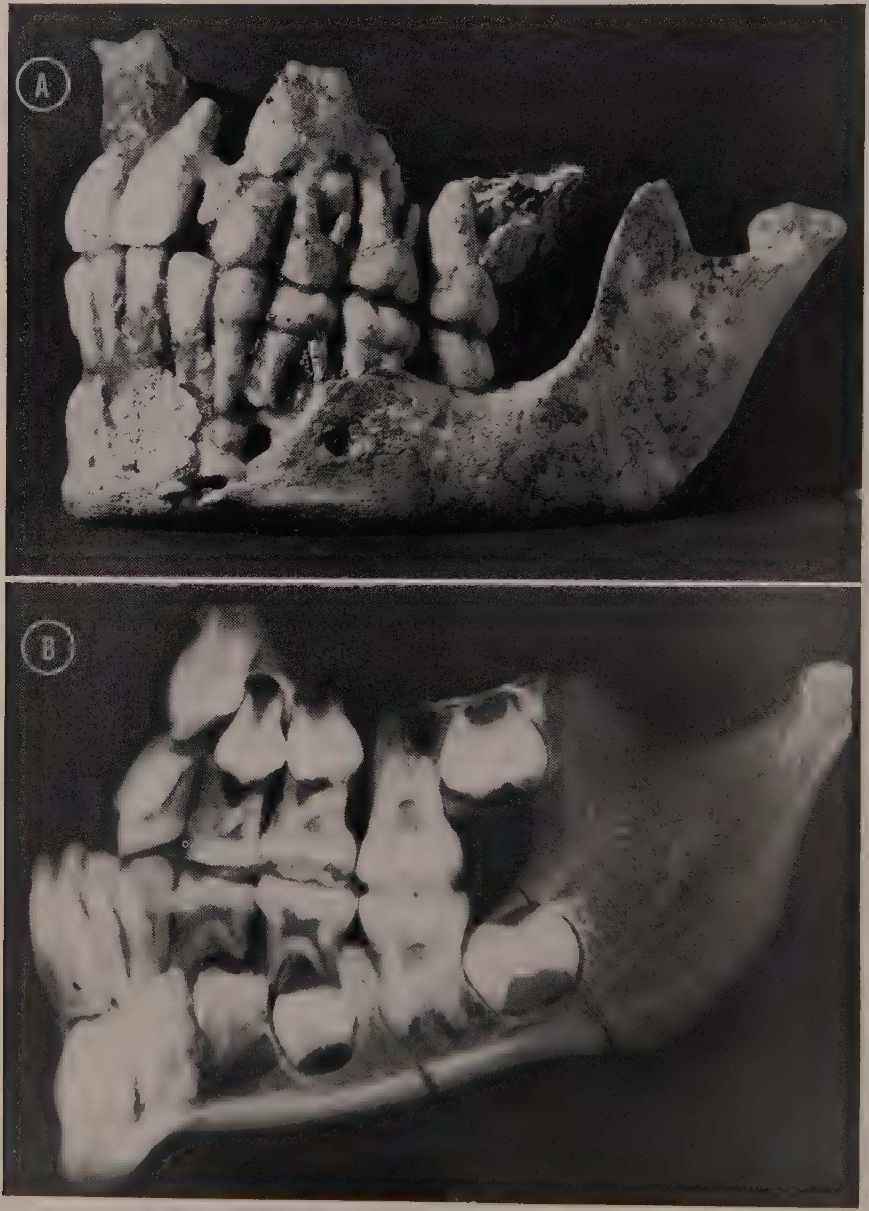


Fig. 3 Antero-lateral view of jaws and radiograph of the Jarmo juvenile SJ2.

In most instances ancestral morphologic pattern was well expressed in the stable teeth (maxillary central incisor, canine, first premolar, and first molar), but it was severely modified in the others which are traditionally variable. (Dahlberg, '49). A brief description of the natural tooth groups one by one will furnish a base for comparison with other dentitions.

Incisors

Four sets of paired maxillary central incisors present approximately similar patterns of non-Mongoloid features and a tapering to ovoid form of crown (fig. 3A). Although lateral marginal ridges are present on the lingual surfaces, these are not pronounced and therefore are not to be classified as shovel-shaped (fig. 4A). The finger-like projections reaching incisally from the basal tubercle or cingulum conform to the type that Weidenreich described in *Sinanthropus*. These projections are not prominent and the fossa consequently has more of a flat to convex appearance. This distinguishes them from the shovel-shaped incisors which show a decided concavity on the lingual of the tooth. It is important to add that our attention here is focussed on the more variable regions of incisor teeth. All teeth have particular areas that show greater variation than do other parts. These variable secondary features, such as the finger-like projections in the incisors, are seemingly not under the same developmental and morphological restraints as are the primary architectural units. They give the impression of "left overs" so to speak, which take the form of convenience rather than of definite plan. Scrutiny of these areas reveals that they most frequently do not have bilateral symmetry of form. It should be stated also that it is not impossible to have bilateral concordance of detailed form in these areas, but generally complete symmetry is rarely seen.

The roots are short compared to the height of the crowns. The lateral incisors, notoriously variable in most populations are reasonably conservative in form in all but one of these individuals, namely the maxillary left lateral incisor of the juvenile (SJ2, fig. 3). This tooth is stunted and appears somewhat like the maxillary left later incisor on the model k of the P2 plaque of the Dental Anthropology series of the Zoller Laboratory. The other incisors show similar lateral marginal ridges and projections as do the central incisors.

The mandibular incisors are of conventional form and moderate in size with little difference between the central and lateral incisors. These teeth generally show little variation in morphology except in size and proportion.

Canines

Both maxillary and mandibular canines are pointed and narrow with relatively little bell shape (fig. 4B). The lingual surfaces of the upper ones show a small cingular eminence and here again the lateral marginal ridges are definitely noticeable but not with very much prominence. No other special morphological characteristics are present.

The mandibular canine shows no special characteristics. It is flat on the lingual surface with only a suggestion of lateral marginal ridging.

Premolars

The maxillary premolars have rather pointed buccal cusps and moderate wrinkling of the occlusal surfaces. The mesial and distal developmental pits are closer together in the second premolars than in the first, thereby leaving only a very short central developmental groove. The first premolars have a long central groove with the pits well over to the mesial and distal margins, respectively (fig. 4C and 4D). The lower premolars have complex occlusal surfaces, divided into a mesial anterior and a distal portion. The lower second premolars are larger, but have less of the oblique shape than the first premolar. None was anomalous or grossly variant in size, although the maxillary second premolars are somewhat smaller than the first.

Maxillary molars

All the permanent maxillary first molars have a rhomboidal shaped occlusal surface with 4 well-developed cusps. Occlusal surface wrinkling is evident. Small Carabelli's cusps (model d, plaque P12)

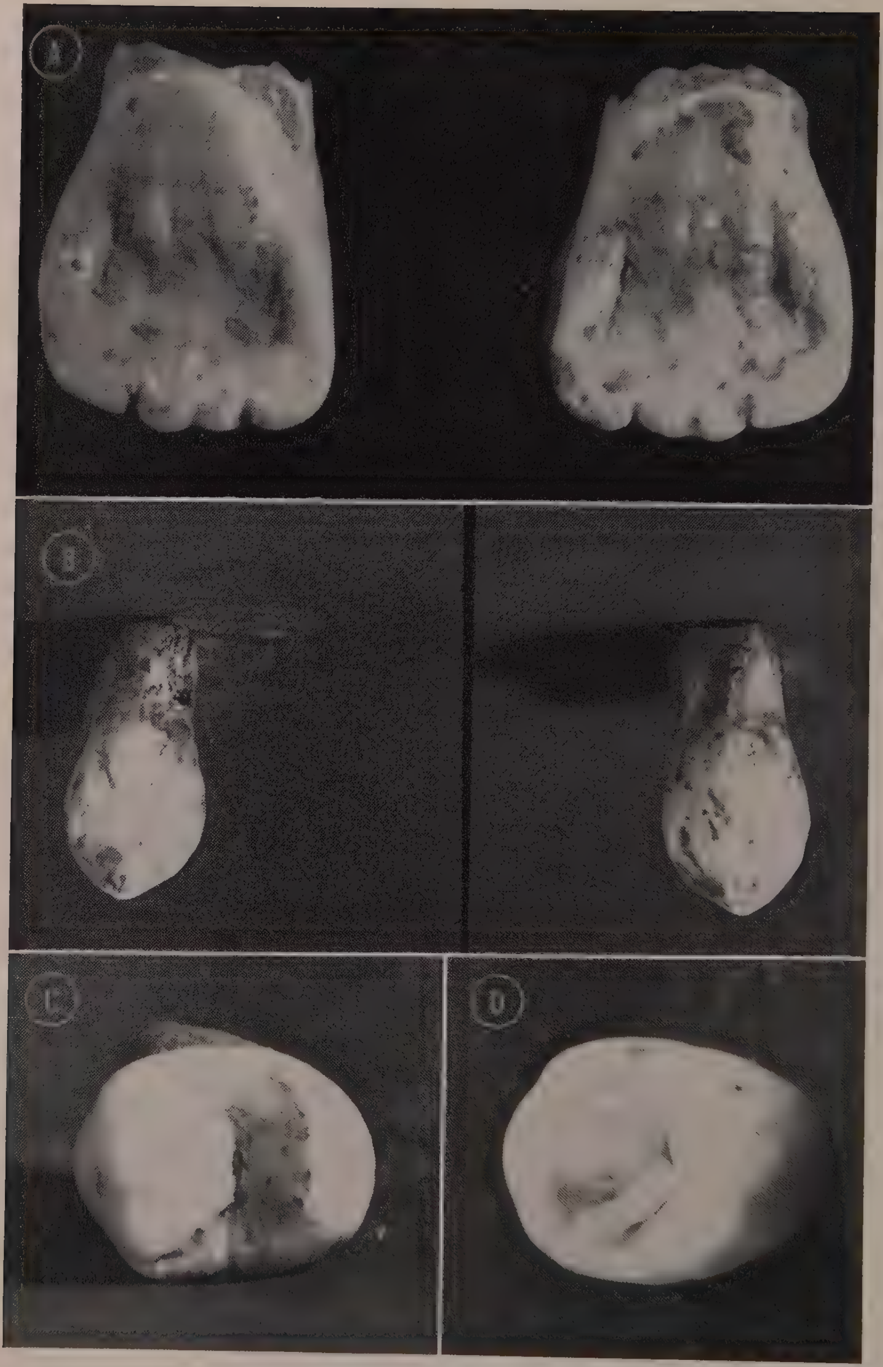


Fig. 4 A, lingual view of permanent maxillary central incisor crowns. B, labial view of permanent maxillary canines. C, occlusal view of maxillary right first premolar. D, occlusal view of maxillary right second premolar.

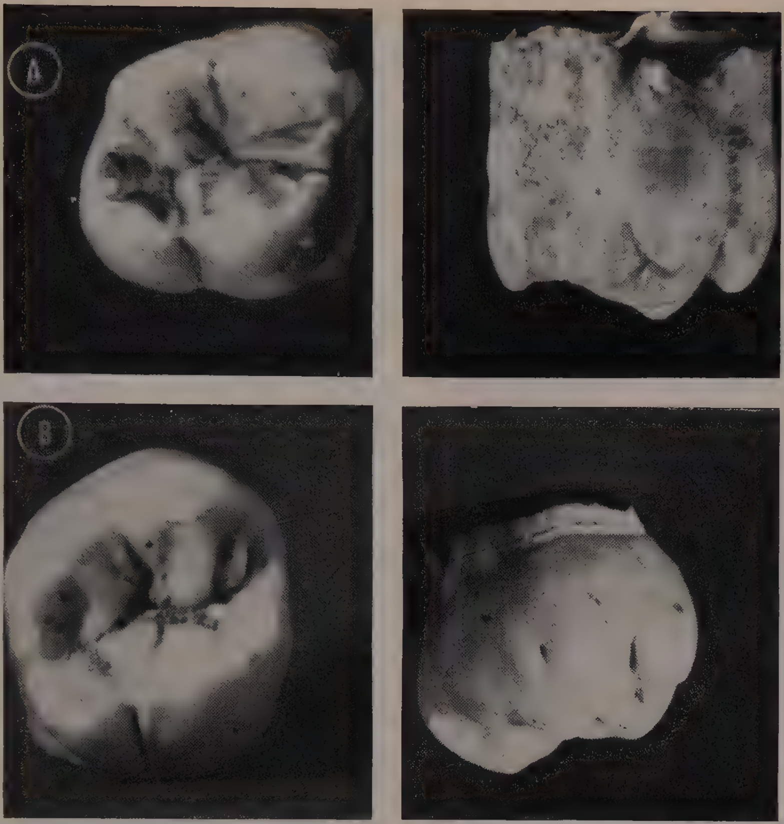


Fig. 5 A, occlusal and mesiolingual view of permanent maxillary right first molar. B, same views of the permanent maxillary right second molar.

re present on the first molars (fig. 5A). owever, only pits are found at this site n the maxillary second molars (fig. 5B). n all the second molars there is a marked eduction in the hypocone (distolingual usp) with complete absence in some instances. The hypocone is one of the most ariable structures in the human dentition s well as being the least conservative part f maxillary molar teeth. Consequently, he fact that this cusp is so definitely modiied in its expression in all the available armo specimens is of importance. The etacone (distobuccal cusp) is not reluced in size whatsoever. This observaion is in contradistinction to the form een in most eastern Mediterranean dentiions.

Mandibular molars

The mandibular molars are similar to hose of modern European and Mediterranean peoples in their occlusal surface morphology. The dryopithecoid Y5 pattern of grooves and cusps is present in the first molars and the +4 pattern is found on the second molars (fig. 6). The third molars available show a 5 cusped tooth with an indication of the typical size and location of cusps producing a + pattern of grooves. There is no indication of any cingular buccal cusps.

One feature of both maxillary and mandibular molars is the larger size of pulp chamber than is generally found in contemporary populations (figs. 1, 3 and 7). In a few instances their character approaches what may be termed a mild taurodontism. The individuals in Matarrah, a later neighboring group of the Jarmoites, have an even greater display of this trait.

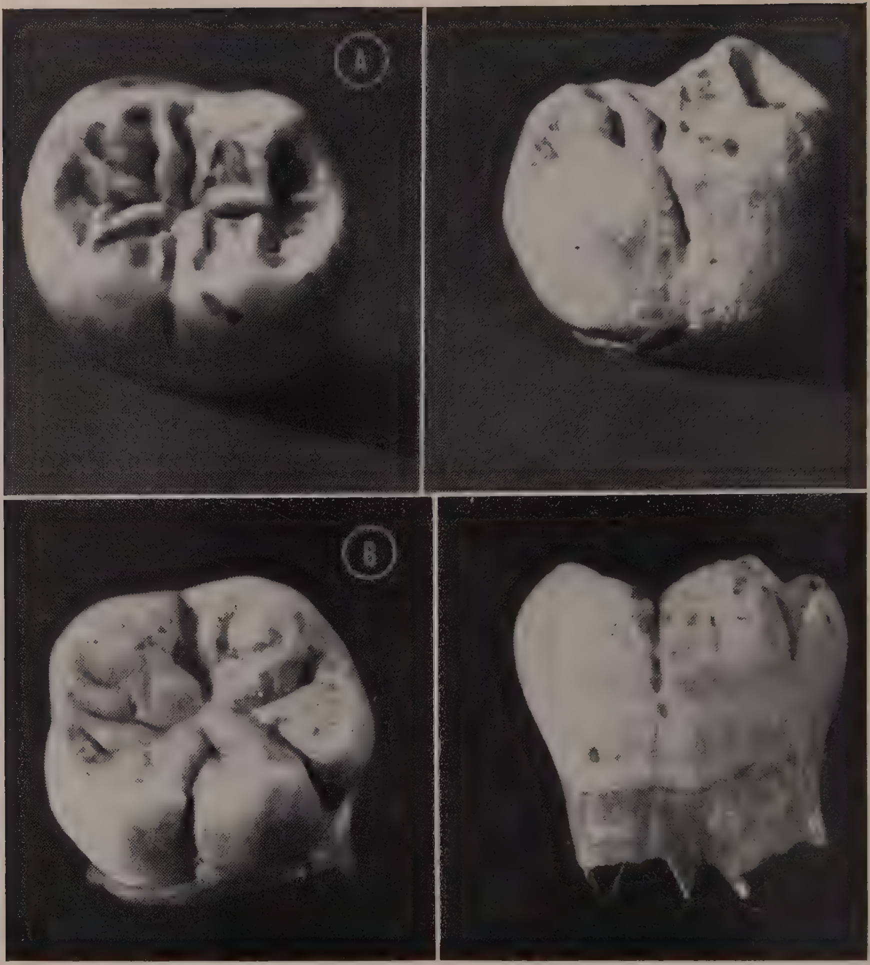


Fig. 6 A, occlusal and buccal views of permanent mandibular left second molar. B, same views of permanent mandibular left first molar.

Deciduous dentition

The deciduous teeth of this group of individuals are of moderate size (tables 5 and 6) and of the conventional Mediterranean-European type (fig. 8). The incisors, particularly, have a bluish cast to the enamel. The long roots of the upper incisors bend labially from the apex to a point midway on the root. No shovel-shaping form is present. The surfaces are generally smooth and rounded. Carabelli's cusp and pit are of a size and form corresponding to those of the permanent teeth. The molar roots diverge with narrow necks at the gingival areas.

Nongenetic features

The nature of the abrasion of the teeth in the older individuals does not suggest the presence of gross, coarse particles in their food. They show, rather, an even milling of the teeth, probably from fine abrasive matter such as silt. No marginal enamel fractures are noted in any of the teeth. A high polish existed on some of the molars. All the teeth of the older individuals are worn flat with exposure of dentin apparent on all the occlusal surfaces. Excessive wear is noted, as is to be expected on the buccal cusps of the lower first molars. These later teeth carry the major

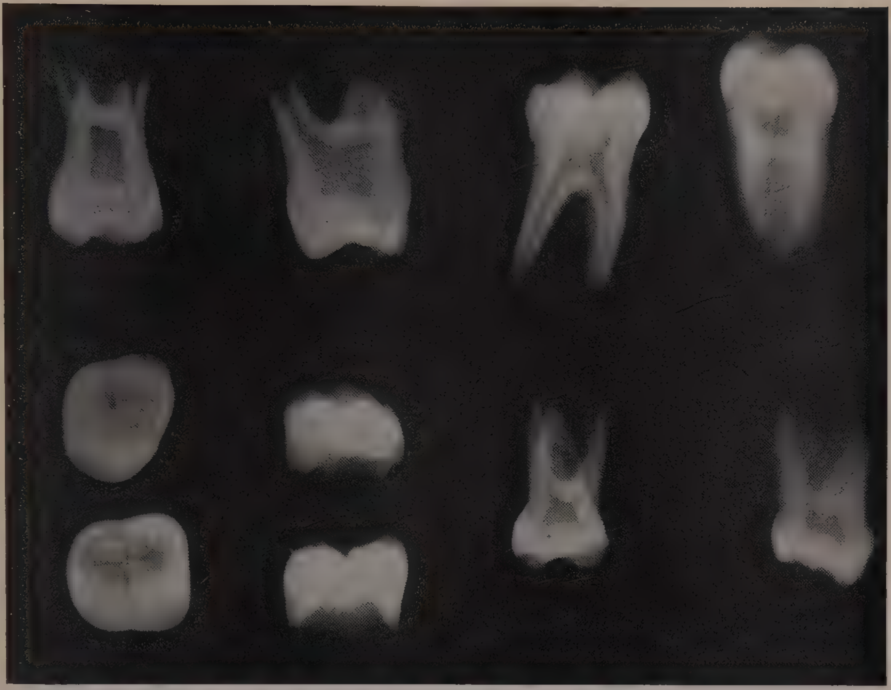


Fig. 7 Radiographs of Jarmo molars showing a mild degree of taurodontism.

load in all populations during the transitional period of change from deciduous to permanent dentition. No exceptional areas of wear are noted that might indicate industries or special uses of the teeth.

Dental caries are found in two of the individuals. One has a cavity in the occlusal surface of a lower deciduous second molar. The other has two interproximal cavities of moderate size and a third one with considerable involvement and a resulting alveolar abscess.

No evidence of pyorrhea or excessive calcular deposits are found in the individuals.

DISCUSSION

Most of the pertinent features referred to in these limited dental evidences of the Jarmo inhabitants are seen to be secondary characteristics, that is, modifications or suppressions of the primary genetic architecture. These phenomena occur in a very orderly fashion in an established sequence within each tooth group and are a sort of measure of penetrance and expressivity. In the case of the Jarmo peoples penetrance and expression of many of the common primary characters is not strong or complete. This suggests the presence of factors which in one way or another impose a negative quantity in a positive manner. These reduced sizes, absences and modifications have been generally attributed to genetic origins and very likely are. Certain Arab groups are known to have a marked and most unexpected reduction in the size of the metacone of the maxillary second molars as well as distinctive inter-tooth-group size proportions. These features are not found in the Jarmo teeth. Rather, the Jarmo dentition resembles more the Indo-European type. It also holds a close resemblance to that of the Anatolians (Senyurek, '52). The teeth are smaller than those of most modern dentitions. Specializations and drift in small populations are of increasing interest. More material from Jarmo is necessary, of course, in order to give real substance to these analyses. The 7 specimens from Jarmo show a consistent trend towards reduced form and size of the dentition. There are also certain characteristics which give a basis for comparison with

TABLE 5

Mesiodistal crown diameters (mm) of decidous teeth of Jarmoites and North American White children

	di 1			di 2			dc			dm 1			dm 2		
	N	M	SE_M	N	M	SE_M	N	M	SE_M	N	M	SE_M	N	M	SE_M
							Maxillary								
Jarmoites	2	6.3		1	4.9		4	6.8		5	7.6		5	9.7	
American Whites	64[1]	6.55	0.05	64[1]	5.32	0.05	65[1]	6.88	0.04	24	6.84	0.03	25	8.87	0.12
							Mandibular								
Jarmoites							3	6.4		5	8.1		5	10.6	
American Whites							65[1]	5.92	0.04	65[1]	7.8	0.05	63[1]	9.83	0.07

[1] Moorrees ('57), figures for males only.

TABLE 6

Labiolingual and buccolingual crown diameters (mm) of deciduous teeth of Jarmoites and North American White children

	di 1		di 2		dc		dm 1			dm 2		
	N	M	N	M	N	M	N	M	SE_M	N	M	SE_M
					Maxillary							
Jarmoites	2	4.8	1	5.0	4	6.1	5	9.0		5	10.5	
American Whites							24	8.22	0.29	26	9.76	0.15
					Mandibular							
Jarmoites					3	5.9	5	7.5		5	9.8	
American Whites							21	7.07	0.13	29	8.84	0.11

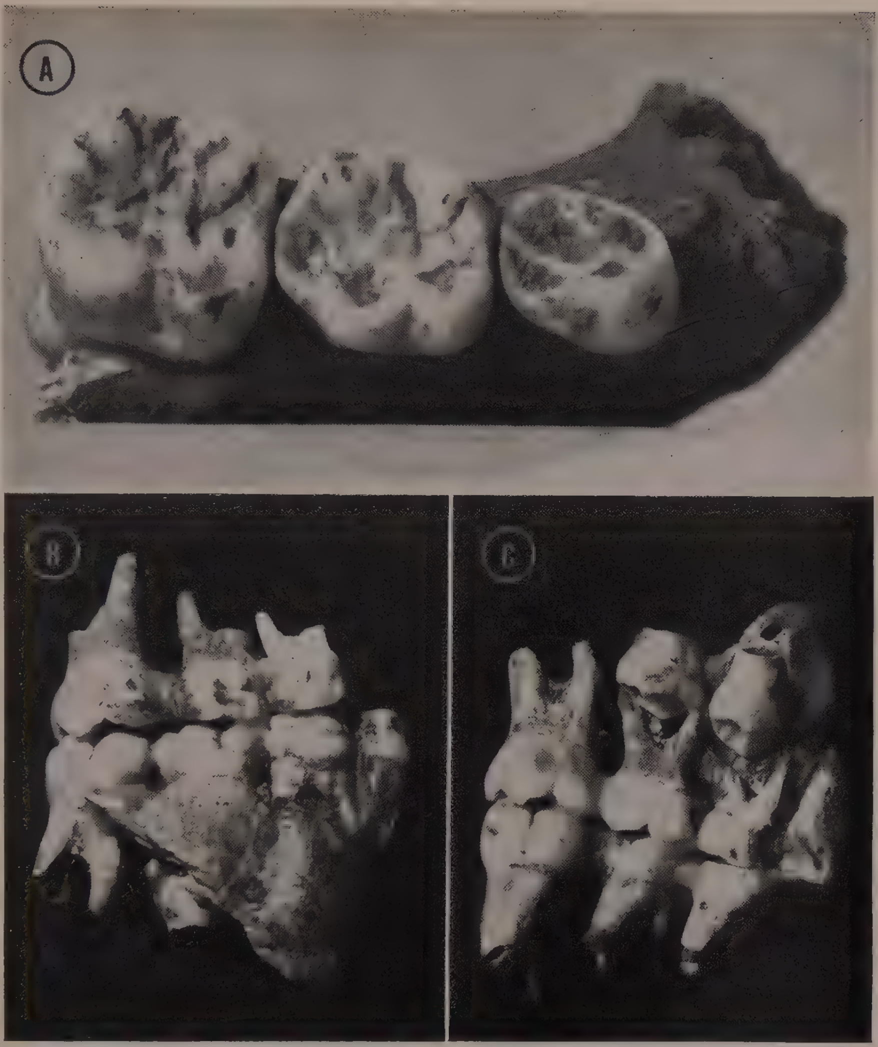


Fig. 8 A, occlusal view of the deciduous mandibular right first and second molars and permanent first molar. B, buccal view of deciduous molars and permanent right first molars. C, lingual view of the same Jarmo specimen.

other populations of this historic era when man first embarked upon the food production phase of his existence.

SUMMARY

Genetic and nongenetic dental features of the early agriculturists of Jarmo, Iraq (6750 ± 500 B.C.) have many similarities to those of the modern Mediterranean and European peoples. They resemble the Iranian and Indo-European more than the others, and have no Mongoloid traits. Ninety-six permanent and 30 deciduous teeth from 7 individuals were available for the study.

There is no irregularity in tooth alignment nor any prognathism. Mild taurodontism is present in some molars. Small modified Carabelli's cusps are present in two of the individuals, making a distinction from the earlier Natufians in whom this cusp is well-developed. No protostylids are present. Hypocones on second and third upper molars are markedly reduced. Shovel-shaped incisor form is absent. Un-

worn teeth have crenated surfaces. Extreme abrasion of the occlusal and proximal surfaces indicate heavy function, but with only mild abrasive assistance. No marginal fractures are present that would suggest gross coarse substances in the diet.

ACKNOWLEDGMENT

Acknowledgment is made to the Iraq-Jarmo project of the Oriental Institute for the dentitions studied and to Professor Theodore McCowan of the University of California for permission to publish the data on tooth measurements of the Natufians.

LITERATURE CITED

Angel, J. L. 1957 Private communications.

Braidwood, R. J. 1958 Near Eastern prehistory. Science, *127:* 1419–1430.

Braidwood, R. J., and L. Braidwood 1953 The earliest village communities of southwestern Asia. J. World History, *1:* 279–310.

Braidwood, R. J., and B. Howe 1960 Prehistoric investigations in Iraqi Kurdistan. Studies in Ancient Oriental Civilization, no. 31, Oriental Institute of the University of Chicago, U. o C. Press.

Childe, V. G. 1947 The Dawn of Europea Civilization, 4th ed. Kegan Paul, Trench an Truber, London.

——— 1952 Man Makes Himself, 3rd ed Mentor, New York.

——— 1957 Civilization, cities and towns Antiquity, *31:* 36–38.

Dahlberg, A. A. 1949 The dentition of th American Indian. In: The Physical Anthropology of the American Indian, William S Laughlin, ed. Viking Fund, Inc., New York.

Moorrees, C. F. A. 1957a The Aleut Dentition Cambridge, Harvard University Press.

——— 1957b Mesiodistal crown diameters o the deciduous and permanent teeth in individuals. J. Dent. Res., *36:* 39–47.

Pedersen, P. O. 1949 The East Greenland Eskimo dentition. Meddelleser am Gronland, p 142.

Senyurek, M. S. 1952 A study of the dentitio of the ancient inhabitants of Alaca Hoyuk Belleten XVI (62): 153–232.

Weidenreich, F. 1937 The dentition of Sinanthropus pekinensis: a comparative odontography of the hominids. Palaeontologica Sinica N.S. D, no. 1.

Variances of Bodily Measurements in the Offspring of Natives of and Immigrants to Three Peruvian Towns

GABRIEL W. LASKER
Department of Anatomy, Wayne State University College of Medicine, Detroit, Michigan

Despite considerable speculation conerning the effect of race mixture on variability of bodily measurements, it remains an open question whether bodily measurements, which have a genetic component, of course, are in fact more variable in the offpring of exogamous matings than in those f endogamous unions. I do not know of empirical data from relatively isolated breeding populations in which this is demonstrated to occur. On the contrary, Kaufmann, Hägler and Lang ('59) studied 8 anthropometric dimension in adult German-speaking Walsers and Romansh speakers in the valleys of Grisons, Switzerand. Each linguistic group was divided into two subseries: (1) those both of whose parents were indigenous to the locale, and (2) those only one of whose parents was a native. Neither males nor females of either group showed a tendency to greater standard deviations in the offspring of immigrants (subseries 2) than in those of natives (subseries 1).

Hulse ('58) also has published data for standard deviations of adult male offspring of village-endogamous and village-exogamous matings among Swiss of Canon Ticino in respect to 12 linear bodily measurements. His data is given separately or those he measured in Switzerland, for migrants measured in California and for American-born offspring of migrants. From his published data I have calculated that of the 36 comparisons possible, 6 show significantly greater variance in the exogamous than in the endogamous groups (at the 5% level of probability by the F-test); two comparisons show the reverse trend. The interpretation of Hulse's material is made difficult by the fact that all of the cases where the exogamous group are more variable occur among either migrants (4 cases) or California-born (two cases) rather than in the more numerous samples measured in Switzerland (among whom the only significant difference is toward greater variability in the endogamous group). Furthermore, among migrants the body weight is also more variable in the offspring of exogamous unions and the other significant differences may be partially dependent on this.

In the present paper I have examined the population of three North Peruvian towns in a similar way. The three communities are Monsefú, a rural town; San José, a fishing village; and Mochumi, another agricultural center. In none of them was there evidence of close inbreeding, but local endogamy is usual in all three. The effective admixture rate is 13%, 25%, and 29% for the three towns, respectively. These rates are slightly lower than the crude counts of immigrants: they were determined merely by asking residents where their parents were born and then calculating the proportion of the total number of answers which list other places. Such rates refer to the previous generation of immigrants and weight the immigration rate in respect to the number of offspring who remain in the community.

I lack a reliable count of the total and adult populations. Furthermore, the variability in family size can only be estimated on the basis of analagous situations elsewhere. Nevertheless, I have attempted to estimate the degree of breeding isolation (Lasker, '59). The *coefficient of breeding isolation* (that is, the product of the size of the effective breeding population by the admixture rate) is approximately 377, 107 and 102 for Monsefú, San José, and

Mochumi, respectively. These values are higher and indicate less isolation than is found in many primitive communities (Lasker, '54); they are lower and indicate more isolation than is to be found in most rural towns of Europe, the United States, or China. The three towns are as isolated as any in the coastal area of the state (departamento) of Lambayeque, Peru, and are probably more or less typical Latin-American peasant communities.

We measured and interviewed 147, 109, and 53 adult females and 104, 95, and 36 adult males in Monsefú, San José, and Mochumi, respectively. The present analysis deals with variability in 16 anthropometric dimensions in the females and 18 in the males. I first divided the series of each sex from each town into three subseries: (1) those whose parents were both born in the town where the subject was measured, (2) those of whom only one parent was born there, and (3) those whose parents were both born elsewhere. For the puproses of this presentation, however, I have in each case lumped the subgroup with one parent born elsewhere together with the subgroup with both parents born elsewhere (2 + 3).[1]

Although a description of the physical types found in the three communities will be left for another occasion, an impressionistic sketch of the people may help in the evaluation of the material now under discussion.

Monsefú is a center of a farming region with small holdings and diversified crops. There is not enough land to support the population, but there is a good deal of craft work and small industry (chiefly weaving, plaiting straw hats and making *chicha* beer on the part of women) and many men hire out as day laborers on haciendas. Certain surnames, some of Indian, some of Spanish derivation, are recognized as belonging to families of the town and there is a well-marked and generally diffused Indian element in the racial make-up of virtually all the inhabitants. Moderately dark complexion, big faces and straight black hair are usual.

San José, the fishing village, is even more dominantly Indian in the appearance of its people. They are generally short but have large chests. The head and face are wide and the face is long with a long co vex nose in most individuals. Although th way of life has little similarity with tha of Peruvian Indians of the Sierra, the phys ical appearance is practically the same it does not suggest a high proportion o European admixture and the prevailin type seems rather constant. There are rela tively few surnames: about one-fourth o the population bears one of them.

Mochumi is a more typical farming com munity. Its people are far more Mestiz or European in appearance than those o the other two places. Many of the inhabit ants are tall and light. The faces and head are narrow on the average. But one als see much variation in physical type wit individuals in whom Indian or eve Negroid rather than European characte istics seem to predominate.

Altogether 102 comparisons are mad between the variance of linear diamete of (1) adult residents both of whose pa ents were born in the town and (2 + 3 adult residents one or both of whose pa ents were born elsewhere. Of all 102 com parisons 70 (69%) tend to show a greate variability in meaurements of the offsprin of immigrants (2 + 3) than in those o two natives (1), and 13 (13%) give significant variance ratio (F) in this direc tion at the 5% level of probability.[2] Onl two of these significant differences pertai to Mochumi, probably because the sma numbers measured require that a diffe ence in this respect would have to be con siderable in order to give statistical signif cance, but one should also note that th variances of measurements of offspring o persons born at Mochumi are already high hence even if immigrants to Mochumi ar as variable as those to the other towns, th variance ratios, F, for the difference be

---

[1] This decision is prompted in part by a pr liminary analysis which shows that the su groups composed of individuals both of who parents were born elsewhere are intermediate b tween the other two subgroups in respect to th mean or variance of several measurements.

[2] In addition, two comparisons (both involvin nose width) show offspring of natives to be mo variable than other residents. No ready explan tion offers itself for this and it seems reasonab merely to test the hypothesis that measuremen of groups (2 + 3), composed of those with pa ents from elsewhere, are more variable than thos of groups 1, and not to test the reverse.

TABLE 1

Variances (mm²) of anthropometric measurements in three North Peruvian communities

	Monsefú				San José				Mochumi			
	Male		Female		Male		Female		Male		Female	
	(1)[1]	(2+3)[2]	(1)	(2+3)	(1)	(2+3)	(1)	(2+3)	(1)	(2+3)	(1)	(2+3)
Number	63–67	37	95–97	49–50	44–46	49	47–49	58–60	13	22–23	19	34
Stature	3039.2	4517.8	2510.2	3173.4	3792.3	4748.6	2768.9	2062.8	4966.9	4579.6	2760.7	4046.7
Biacromial	306.1	* 557.9	244.3	* 414.8	250.2	* 417.8	419.3	329.0	452.1	397.1	337.5	400.6
Chest width	495.9	673.2	514.3	** 915.7	367.3	282.6	844.1	695.1	229.0	415.3	289.2	565.9
Chest depth	310.4	432.6			380.3	374.5			335.2	312.9		
Arm length	718.9	982.6	815.6	930.6	821.4	1096.1	1393.6	1041.1	2258.3	1857.6	951.5	1066.5
Radius length	109.9	* 178.7	154.2	155.6	158.1	206.4	159.5	114.1	324.7	228.6	180.7	158.4
Tibia length	388.9	290.7			302.8	* 557.1			736.4	436.4		
Head length	37.08	48.35	39.03	34.37	18.89	* 34.72	36.24	49.35	11.67	* 29.78	20.78	39.00
Head breadth	49.52	48.01	30.06	37.72	32.10	42.41	40.09	50.14	16.24	31.91	49.67	29.71
Minimum frontal	22.71	23.30	15.70	15.64	15.51	18.09	16.24	17.31	21.21	16.06	24.65	20.50
Bizygomatic	23.35	* 37.73	19.80	20.97	18.84	25.61	23.86	* 39.81	6.69	16.34	26.21	27.34
Bigonial	29.19	33.49	28.85	34.00	40.14	54.41	22.49	23.80	33.44	64.75	21.75	22.42
Menton-Nasion	30.17	** 60.17	29.98	31.13	37.68	57.02	28.77	35.42	52.15	45.65	9.01	* 25.73
Nose height	14.43	13.29	13.49	16.10	13.75	* 24.67	10.86	12.92	16.22	11.06	7.53	10.73
Nose breadth	8.62	13.47	13.23	** 6.81	12.51	12.63	9.89	13.86	19.62	** 6.25	9.53	6.29
Interocular	7.55	7.65	8.75	6.11	5.62	6.57	6.29	9.23	8.70	6.69	7.29	8.10
Hand length	54.02	63.71	62.62	68.33	67.02	72.98	59.62	70.88	70.56	91.79	63.25	62.07
Hand breadth	15.79	16.41	11.50	10.86	21.12	25.45	12.50	17.16	18.77	19.42	19.20	16.61

[1] (1) Adult residents both of whose parents were born in the town where the individual was measured.

[2] (2+3) Adult residents one or both of whose parents were born elsewhere.

* The variances which precede and follow this symbol are significantly different from each other by F-test at the 5% level of probability for one tail of the distribution.

** Same, at the 1% level.

tween 1 and (2 + 3) at Mochumi would be low.

Of the 6 instances at Monsefú and 5 at San José in which the offspring of natives are significantly less variable than other residents, 4 of each are in males. Only one reason suggests itself as a partial explanation for a sex difference in this regard. Since some of the persons with one or both parents born elsewhere are first-generation migrants to the town, and since males are generally mobile over greater distances than females, it is possible that males both of whose parents were born elsewhere are more variable than the comparable females because those of the males who are first-generation migrants come from a wider variety of places. As a matter of fact, however, when one separates individuals with one parent born elsewhere (2) from those with both parents born elsewhere (3), the instances in which the latter are significantly more variable than the former occur primarily in females. This occurs in all 4 significant differences for Monsefú, 4 of 6 for San José, and there is no such case for Mochumi.

In respect to the specific measurements which show significant *F*-scores between subseries 1 and subseries 2 + 3, all also show significant *F*-scores between subseries 1 and subseries 2 or between subseries 1 and subseries 3 separately. Among the males, 5 of the 9 significant *F*-scores of this kind depend primarily on the significantly high variability in offspring of two non-natives of the community (subseries 3) relative to the offspring of natives (subseries 1) and the other 4 depend primarily on a significantly greater variability in subseries 2 than in subseries 1. Among the 4 significant *F*-scores between subseries 1 and 2 + 3 in females, there is also a significant difference between subseries 1 and 2 in all cases and also a significant difference between subseries 1 and 3 in one instance.

In comparisons of offspring of two native-born persons (1) with all other residents (2 + 3), the significant *F*-scores are not limited to one measurement nor a single kind of measurement, but occur in the extremities, trunk, head and face. Although there are also a number of significant differences in the means between these series, only one of the 15 such which are significant at the 5% level of probability by the *t* test also shows a significant difference in variance; that is, the tendency of migration to increase the variation is manifest in different dimensions from those indicative of its tendency to alter the type.

Our data demonstrate that in moderately isolated communities — especially where one of the elements of the population (in this case Indian) seems more dominant than in other communities of the region—one effect of immigration may be an increase in variability of physical traits as reflected in variances of anthropometric measurements. Since race mixture itself does not necessarily always lead to increased variability of the population, and since there are cases on record where the offspring of one immigrant parent are not more variable than those of two natives of the community, it may be useful to have on record these examples of the process by which variability in certain aspects of physique increase through exogamy in three communities the breeding structure of the populations of which is known.

SUMMARY

In residents of three North Peruvian communities, variances of some bodily measurements are shown to be higher in adult offspring of one or two immigrant parents than in adult offspring of natives. In three moderately isolated communities with effective immigration rates of 13 to 29% per generation, there are 13 of 102 comparisons in which the variance ratio, *F*, shows a statistically significant greater variability (at the 5% level) in persons with one or both parents born elsewhere than in persons of the same sex both of whose parents were native to the community. These significant differences occur in measurements of all regions of the body (trunk, limbs, head and face) and in both sexes (9 in males, 4 in females); only one of them occurs in one of the 15 comparisons where there is also a significant difference in the means. In this study one effect of migration into the communities is increase in variability of bodily measures

ments of the adult population in the succeeding generation.

LITERATURE CITED

Kaufmann, H., K. Hägler and R. Lang 1959 Analyse anthropologique et statistique de Walsers orientaux et de Romanches de l'Oberhalbstein (Grisons, Suisse). Extrait des Arch. Suisses d'Anthrop. Générale, (1958), *23:* 1–328.

Hulse, F. S. 1957 Exogamie et hétérosis. Ibid., *22:* 103–125.

Lasker, G. W. 1954 Human evolution in contemporary communities. Southwestern J. Anthrop., *10:* 353–365.

——— 1959 An index of the breeding isolation of communities: Peru. Manuscript. Abstract, submitted to the Proceedings of the Am. Assoc. Phys. Anthrop.

A Familial Study of Torus Palatinus and Torus Mandibularis[1]

MAKOTO SUZUKI AND TAKURO SAKAI
Department of Anatomy, Shinshu University School of Medicine, Matsumoto, Japan

Torus palatinus is a spindle-shaped bony elevation along the midline of the vault of the palate. Torus mandibularis is a bony elevation on the lingual surface of the mandible, with its center approximately at the apex of root of the mandibular second premolar. Both exostoses usually appear in the form of a swelling or a series of swellings. Concerning torus palatinus and torus mandibularis, many different anthropological studies of various populations have been reported since the former was named in 1880 by Kupffer and the latter in 1908 by Fürst. According to the findings, these tori occur, generally speaking, with a higher frequency among populations living in the northern hemisphere such as the Ainu, Eskimo, Icelanders, or Lapps, than among populations in the southern regions. Drennan, however, reported in 1937 that the two tori are seen at a rate of more than 80% in the Bushmen's palate and mandible.

In relation to age, torus palatinus and mandibularis are reported to be scarcely present in the jaw of individuals younger than 20 years, but recent anthroposcopic observations proved that both these exostoses, though not fully developed, can be definitely recognized already in infancy. Woo ('50) observed that "torus palatinus may be present prenatally and gradually increase in size from birth to maturity. Approximately 20 years of age it ceases to grow, in accord with other bony structures, and does not increase in age." Moorrees ('52, '57) also reported that "torus mandibularis can be present in the young, at least in an Aleut population. It is, however, quite likely that the final degree of development of torus is not expressed until the adult age is reached."

With regard to sex differences in their frequencies, Woo ('50) and Miller and Roth ('40) as well as others reported that torus palatinus is observed more frequently in the female, while Hrdlička ('40) arrived at an opposite conclusion. The frequency of torus mandibularis in males seems higher among many populations than that in females, but Akabori reported reversely in 1939. Thus, the validity of these sex differences has not yet been established completely.

The etiology of these exostoses has been a source of various arguments and no definite conclusion has been attained so far. Kajava ('12), Hooton ('18), and Hrdlička ('40) support the functional hypothesis arguing that both tori are closely connected with the chewing function and must have been caused by the hyperfunctional stress on the jaws because they are scarcely seen in children, increase in size with age, and have a close relationship with attrition. On the other hand, Schreiner ('35), objected to this functional hypothesis, stating that: although torus palatinus is generally observed in jaws with markedly worn teeth, these tori are also recognized in skulls where there is no wear of the teeth whatsoever, while torus palatinus exists in the hard palates of new-born babies which have not been subjected to mechanic stimuli. Schreiner concluded that the tori are localized bone growths due to abnormal sensitivity of the bone conditioned by "deficient diet or avitaminosis." Van den Broek ('43, '45) also reported that these tori are localized development of bone caused by "the chemical irritation of the mucous membrane."

---

[1] This report consists mainly of material presented at the 11th Joint Meeting of the Anthropological Society of Nippon and the Japanese Society of Ethnology held at Nara in October, 1956.

This study was supported by the Scientific Research Fund of the Educational Ministry of Japan.

On the other hand, Carabelli (1842), Godlee ('09), Körner ('10), Dorrance ('29), Greifenstein and Dieminger ('38), Lasker ('47), and Moorrees et al. ('52), attached greater importance to inheritance rather than to environment. The last mentioned author stated that these tori are inheritable traits on the basis of their familial incidence and the result of a genetic study.

Thus, as to the cause of these exostoses, some investigators adhere to a functional hypothesis, others stress the importance of biological effects, or of genes. In spite of the many different hypotheses, all reports agree on one point, namely, that these tori are not a disease but a physiological phenomenon.

Since 1953 the authors have been in a position to collect data on the Japanese in several parts of Nagano Prefecture which afford an opportunity to determine the frequency of torus palatinus and torus mandibularis in families in order to test their genetic origin.

MATERIALS AND METHODS

The data of this study are the result of studies conducted in Matsumoto-city, Ono-village, and Tatsuno-town, of Nagano Prefecture from June 1953 to September 1957. The existence of torus palatinus and torus mandibularis was ascertained by palpation and visual inspection.

As Woo ('50) mentioned, it is not always easy to discern the border of torus palatinus when its development is very slight because of the masking by soft tissues. However, generally speaking, the hard palate and the lingual surface of the mandible are flat and therefore the authors were able to recognize fairly accurately the boundaries of the tori as they became trained in examining these structures.

The degree of their development was classified in three categories as follows:

Trace—not discernible by sight but clearly recognized by palpation; slight—discernible by sight; marked—particularly remarkable.

In the case of asymmetric development of torus mandibularis, the classification was based on the side exhibiting the greater degree of torus development.

RESULTS AND DISCUSSION

In total, approximately 150 familie were studied. The number of children an mean ages of parents and offspring ar presented in table 1 for 62 families o which the parents and all siblings olde than 4 years of age could be examine Before undertaking the genetic analysi the authors tested whether the palatin and mandibular torus are significantly concurrent in individuals, as is shown in tabl 2. According to a chisquare of 25.36 th correlation of the two features is statistically significant. The relation betwee the presence of torus mandibularis an torus palatinus in parents and their chi dren are shown in tables 3 and 4.

When both parents have a torus palatinus, the frequency of its occurrence i their children is 63.9%. In families wher either the father or the mother have thi torus, the frequency in their children i 52.3%. Moreover, in families where toru palatinus is absent in both parents, th frequency of its occurrence in the childre is only 7.9%.

When both parents have a torus mandibularis, the frequency of its occurrence i their children is 58.6%. In families wher either the father or the mother have thi torus, the frequency in their children i 40.0%. In families where torus mandibularis is absent in both parents, the frequency in the children is only 4.9% (table 3).

In addition to examining the associatio of the presence of tori in parents and the children, it was determined also whethe the degree of their development was related, as shown in table 4. The numbers i brackets in the column of the combinatio of parents denote "weighted" values fo the tori of the parents. Following Hrdličk

TABLE 1

Number, sex and age of individuals studied

Sex	Number of individuals	Average age
		years
	Parents	
Male	62	41.0
Female	62	38.3
	Children	
Male	97	12.1
Female	88	11.5

TABLE 2

The correlation between the torus palatinus and mandibularis

	Torus palatinus			
Torus mandibularis	Absent	Slight	Medium	Marked
Absent	50	12	6	6
Slight	5	10	0	2
Medium	7	5	3	3
Marked	6	2	3	4

TABLE 3

The relation of torus palatinus and torus mandibularis in parents and children

Parents[1]	Number of families	Number of individuals	Children: Torus Present	Children: Torus Absent	Frequency of occurrence
					%
		Torus palatinus			
■ × ●	11	36	23	13	63.9
■ × ○	12	32	17	15	53.1
□ × ●	18	54	28	26	51.9
□ × ○	21	63	5	58	7.9
		Torus mandibularis			
■ × ●	9	29	17	12	58.6
■ × ○	20	55	21	34	38.2
□ × ●	11	40	17	23	42.5
□ × ○	22	61	3	58	4.9

[1] Solid symbols denote presence of a torus and open symbols, its absence. Square symbols are used for males and round symbols for females, as is customary.

TABLE 4

The relation of torus palatinus and torus mandibularis in parents and children

Degree of torus development in parents[1]	Number of families	Children: Total	Children: Marked	Children: Slight	Children: Trace	Children: Absent	Frequency of occurrence	Degree (weighted value) of torus development
							%	
		Torus palatinus						
Marked-marked and marked-trace (66.7)	3	7	2	2	3	0	100.0	46.4
Slight-trace (37.5)	4	15	0	5	4	6	60.0	23.4
Trace-trace (25.0)	4	14	0	1	6	7	50.0	14.3
Marked-absent (37.5)	7	22	4	3	7	8	63.6	25.0
Slight-absent (25.0)	6	17	0	0	8	9	47.1	11.8
Trace-absent (12.5)	17	47	2	1	20	24	48.9	14.9
Absent-absent (0)	21	63	0	2	3	58	7.9	2.8
		Torus mandibularis						
Marked-marked, marked-slight and marked-trace (57.5)	5	16	1	2	6	7	52.2	20.3
Trace-trace (25.5)	4	13	0	2	6	5	61.5	19.2
Marked-absent (37.5)	7	20	0	3	7	10	50.0	16.3
Slight-absent (25.0)	13	37	0	5	7	25	32.4	11.5
Trace-absent (12.5)	11	38	2	1	13	22	42.1	15.1
Absent-absent (0.0)	22	61	0	1	2	58	4.9	1.6

[1] Figures in parentheses show the "weighted" value for torus development in parents.

the slight degree of development is counted as 25, medium as 50, and the marked degree as 75; the "weighted" value reported is the average of the total number of cases in each category.

According to table 4, it may be concluded that the more marked the development of torus palatinus is in the parents, the higher is its frequency of occurrence and development in their children. A comparison of the "weighted" values of the parents to that of their children shows, however, that the degree of development in the children is less marked than that in the parents. It is assumed that age differences explain this lack of complete concordance of the degree of torus development in parents and their offspring. Therefore, if families whose members are all older than approximately 20 years of age are examined, the rate of occurrence may be higher and the degree of development more marked in the siblings. Unfortunately it is by no means easy to obtain such material. The same conclusions were made with respect to torus mandibularis.

Summarizing, it may be stated that the two tori in parents and in their children appear to have a close correlation in the frequency of their occurrence and development but since the number of subjects studied is not sufficiently large and the children young in age, the authors do not want to consider their findings as a definite conclusion.

In table 5 the relation of tori in the children and their parents is shown. When the children have a torus palatinus, 20%
of both their parents also have torus pal
tinus; while 65.7% of one parent has th
torus. In other words, if the children hav
a torus palatinus, 85.7% of one or both c
their parents show the presence of th
exostosis. When the torus is absent in th
children, it occurs only in 23.8% of on
parent.

When torus mandibularis occurs in th
children, 19.3% of both their parents als
have torus mandibularis; while 70.2% c
one parent shows its presence. Thus,
the children have a torus mandibulari
89.5% of one or both of their parents als
show its presence. In the case of an ab
sence of torus mandibularis in the chi
dren, it occurs only in 26.9% of one c
both of their parents (table 5).

Analyses of the pedigree charts (fig
1–7) concerning these tori add importan
additional information on the genesis c
the exostoses. Family no. 1 shows a lo
frequency of their occurrence, and famil
no. 3 shows a high incidence. Accordin
to these data the majority of the childre
whose parents have either or both of th
tori, have these exostoses also. If the pa
ents have markedly developed tori, the
children have a high frequency of the
occurrence. Moreover, their developme
can be classified as marked and they ap
parently occur even at young ages. I
can be concluded that torus palatinus an
torus mandibularis are inheritable traits—
presumably explained by a Mendelia
dominant gene—though this assumptio
may not exactly reveal the true mode of in
heritance. The disagreement, if any, be

TABLE 5

The relation of torus palatinus and torus mandibularis in children and their parents

Children	Number of individuals	Parents[1]			Total
		■	●	■ × ●	
		Torus palatinus			
With torus palatinus	70	18 (25.7)	28 (40.0)	14 (20.0)	60 (85.7)
Without torus palatinus	21	2 (9.5)	3 (14.3)		5 (23.8)
		Torus mandibularis			
With torus mandibularis	57	22 (38.6)	18 (31.6)	11 (19.3)	51 (89.5)
Without torus mandibularis	26	5 (19.2)		2 (7.7)	7 (26.9)

[1] Solid symbols denote presence of a torus and open symbols, its absence. Square symbols are used for males and round symbols for females, as is customary. Figures in parentheses refer to the percentage frequencies.

veen assumption and actual fact is due to e age differences of the subjects examed and to our unsatisfactory method of amining the living.

Lasker's studies of torus palatinus and rus mandibularis in 5 families show utosomal dominant inheritance" as well "sex-linked dominant inheritance" for rus palatinus and also "a high penetrance cause of the tendency toward bilateral mmetry in individuals" for torus mandibaris.

Osborne (in Moorrees, '52, '57) reported at there is only a low correlation in eeuts between parents and offspring in e degree of the development of torus andibularis, but that the coefficient of rrelation among siblings is very high, beg + 0.72. He also reported that "at least ree independent loci affecting torus delopment must be assumed."

SUMMARY

Through the genealogical research of rus palatinus and torus mandibularis of 2 families living in the Nagano Prefecre, the following results were obtained:

1. The concurrence of the palatine and andibular torus is statistically signifiant in individuals.

2. When both parents have either torus latinus or torus mandibularis, the rate occurrence of these tori in their children higher than when a torus is found in ly one of the parents. When tori are sent in parents the frequency in their ildren is very low.

3. The tori in parents seem to correlate osely with those of their children with gard to the degree of their development.

4. When the children have torus palaus or torus mandibularis, 85.7 or 89.7% either or both of their parents likewise ve these tori.

5. Torus palatinus and torus mandiburis are presumably considered as of the minant inheritance.

ACKNOWLEDGMENTS

The authors thank Professor Tsunekichi eda of the Nara Prefectural Medical Colge for his valuable advice and they also fer their gratitude to the many people ho have been kind enough to assist in is investigation.

LITERATURE CITED

Akabori, E. 1939 Torus mandibularis. J. Shanghai Sci. Inst., *4:* 239–257.

Dorrance, G. M. 1929 Torus palatinus. Dent. Cosmos, *71:* 275–285.

Drennan, M. R. 1937 The torus mandibularis in the Bushman. J. Anat., *72:* 66–70.

Fürst, C. M. 1908 Torus mandibularis bei den Eskimos und anderen Rassen. Anat. Anz., *32:* 295–296.

Godlee, R. J. 1909 The torus palatinus. Proc. Royal Soc. Med., Surg. Sect., *2:* 175–196.

Griefenstein, A., and K. Dieminger 1938 Erblichkeit und klinische Bedeutung des Gaumenwulstes (Torus palatinus). Erbblätter Hals-Nasen- und Ohrenarzt, *3–4:* 43–54.

Hooton, E. A. 1918 On certain Eskimoid characters in Icelandic skulls. Am. J. Phys. Anthrop., *1:* 53–76.

Hrdlička, A. 1940 Mandibular and maxillary hyperostoses. Ibid., *27:* 1–55.

Kajava, Y. 1912 Die Zähne der Lappen. Suomen Hammaslääkäriseuran Toimituksia. Finska Tandläkarsällskapets Forhandlingar, *10:* 1–64.

Körner, O. 1910 Der torus palatinus. Zeitschr. Ohrenheilkd., *61:* 24–27.

Kupffer, C. 1880 Gaumenwulst, Torus palatinus. Corr.-Bl. Anthrop. Ges., *11:* 44–45.

Lasker, G. W. 1957 Penetrance estimated by the frequency of unilateral occurrences and by discordance in monozygotic twins. Human Biol., *19:* 217–230.

——— 1950 Genetic analysis of racial traits of the teeth. Cold Spring Harbor Symposia on Quantitative Biology, *15:* 191–203.

Miller, S. C., and H. Roth 1940 Torus palatinus: a statistical study. J. Am. Dental Assoc., *27:* 1950–1957.

Moorrees, C. F. A. 1957 The Aleut dentition. A correlative study of dental characteristics in an Eskimoid people. Harvard Univ. Press, Cambridge.

Moorrees, C. F. A., R. H. Osborne and E. Wilde 1952 Torus mandibularis: its occurrence in Aleut children and its genetic determinants. Am. J. Phys. Anthrop., *10:* 319–329.

Sakai, T. 1954 Anthroposcopic observations of palatine and mandibular tori in Japanese. Shinshu Igaku-Zassi, *3:* 303–307.

Schreiner, K. W. 1935 Zur Osteologie der Lappen. Instituttet for Sammenlignende Kulturforskning, Series B, *18:* 161–177.

Stieda, L. 1891 Der Gaumenwulst (Torus palatinus). Int. Beitr. Wiss. Med., *1:* 145–176.

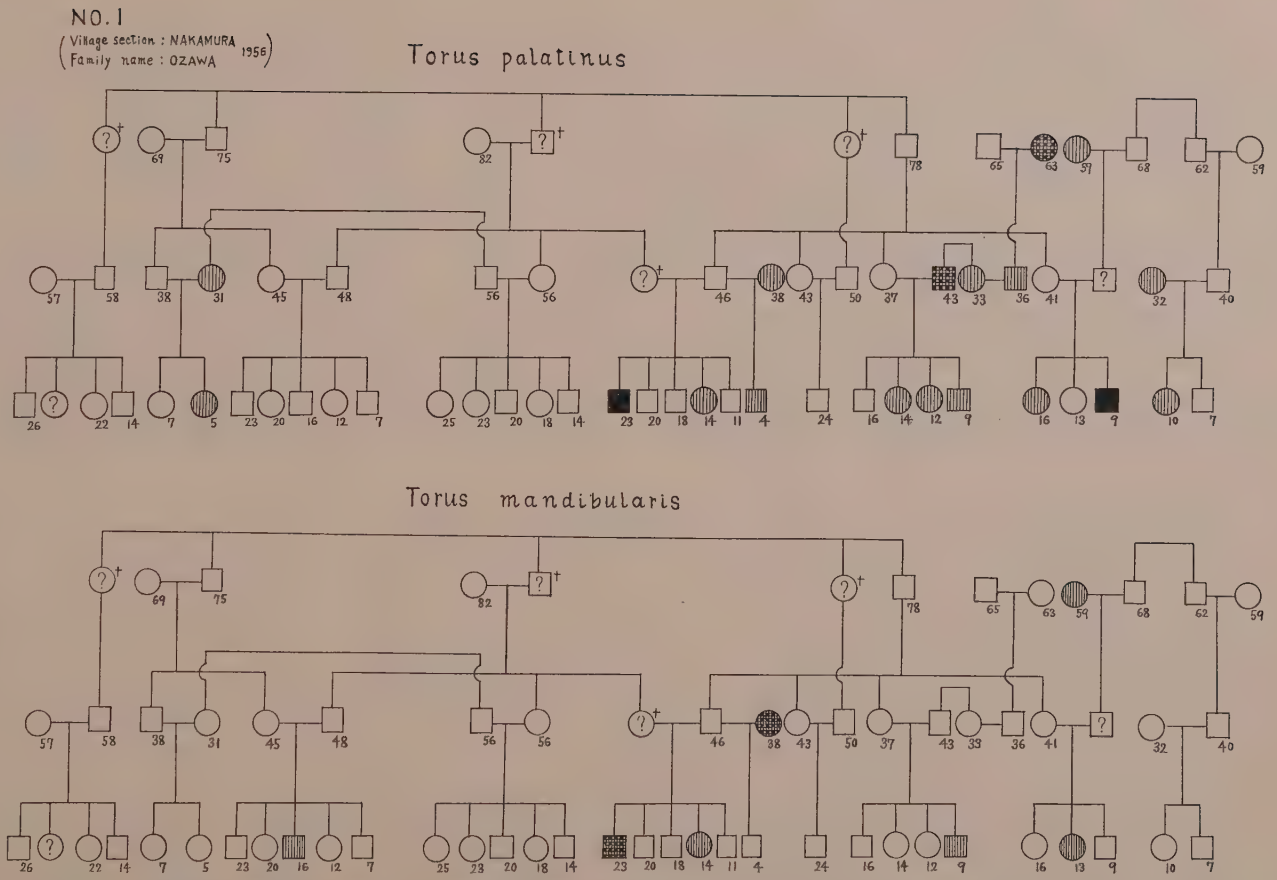
Suzuki, M. 1941 Anthropologischen Untersuchungen der einzelnen Abschnitte der Schädel von den Mongolen, Chinesen und Koreanern. II. Teil, Mandibulare und Maxillare Hyperostosis. Anthrop. Papers, A, Anthropology, No. 3: 103–132, Tokyo.

Thoma, K. H. 1937 Torus palatinus. Int. J. Orthodonties Oral Surg., *23:* 194–202.

van den Broek, A. J. P. 1943–45 On exostoses in the human skull. Acta Neerland. Morph., *5:* 95–118.

Von Carabelli, G. 1842 Anatomie des Mundes. Systematisches Handbuch der Zahnheilkunde. Braumuller und Seidel, Wien.

Woo, J. 1950 Torus palatinus. Am. J. Phys. Anthrop., *8:* 81–112.



Figs. 1–7 Pedigree charts showing incidence of forms palatinus and torus mandibularis in 7 families. The small figures indicate the age of each individual; the symbol * refers to deceased persons. Key: Vertical shading indicates "trace"; checkered shading indicates "slight"; solid black indicates "marked."

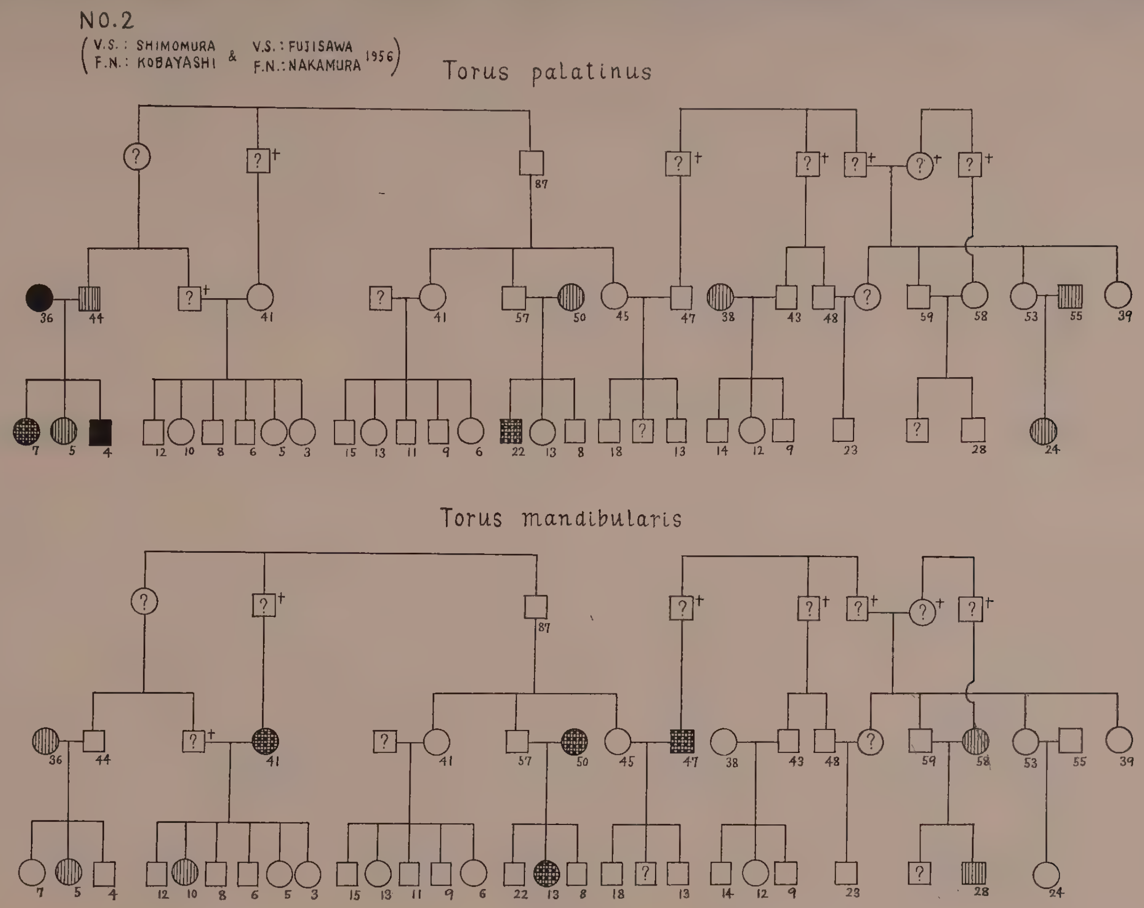
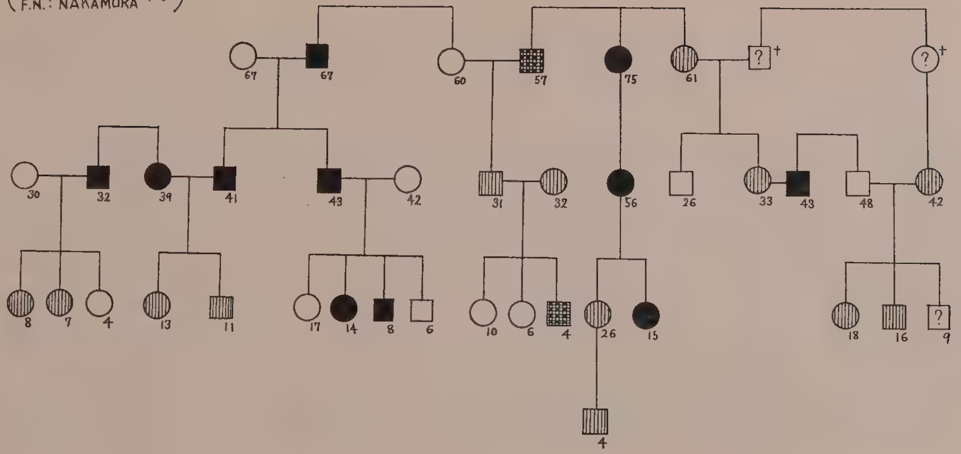

NO.2
(V.S.: SHIMOMURA & V.S.: FUJISAWA
F.N.: KOBAYASHI F.N.: NAKAMURA 1956)
Torus palatinus
? ?+ 87 ?+ ?+ ?+ ?+ ?+
36 44 ?+ 41 ? 41 57 50 45 47 38 43 48 ? 59 58 53 55 39
7 5 4 12 10 8 6 5 3 15 13 11 9 6 22 13 8 18 ? 13 14 12 9 23 ? 28 24
Torus mandibularis
? ?+ 87 ?+ ?+ ?+ ?+ ?+
36 44 ?+ 41 ? 41 57 50 45 47 38 43 48 ? 59 58 53 55 39
7 5 4 12 10 8 6 5 3 15 13 11 9 6 22 13 8 18 ? 13 14 12 9 23 ? 28 24

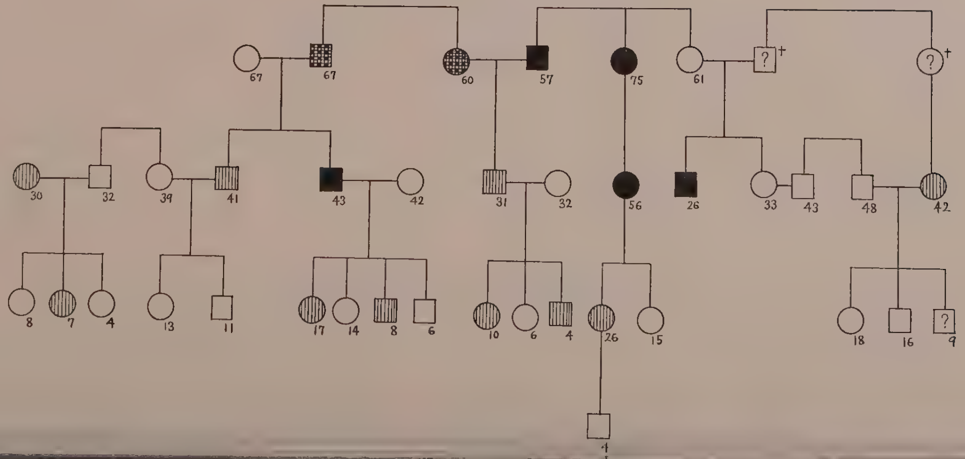
Figure 2

NO. 3
(V.S.: FUJISAWA / F.N.: NAKAMURA 1956)

Torus palatinus

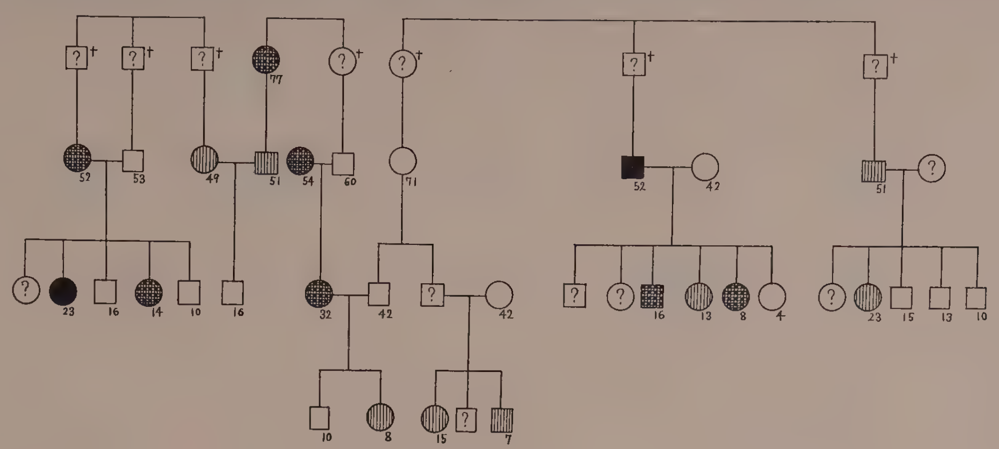


Torus mandibularis



No. 4
(V.S.: SHIMOMURA 1956
F.N.: ENDŌ)

Torus palatinus



Torus mandibularis

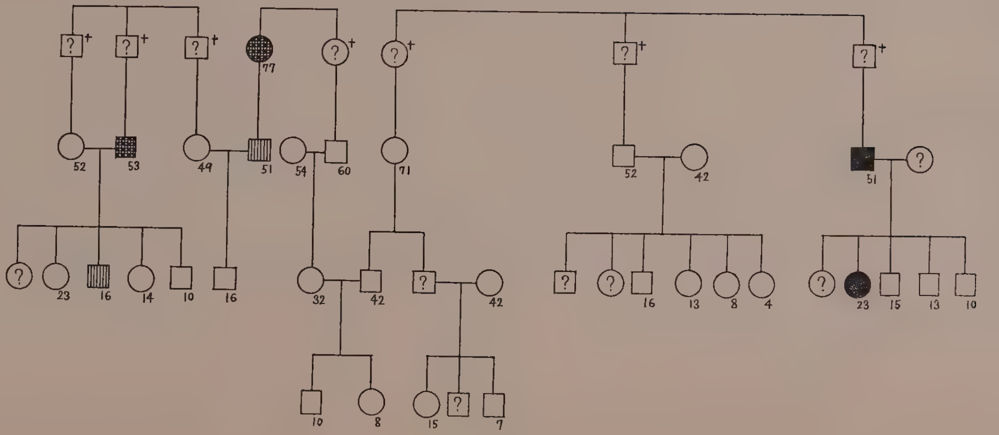
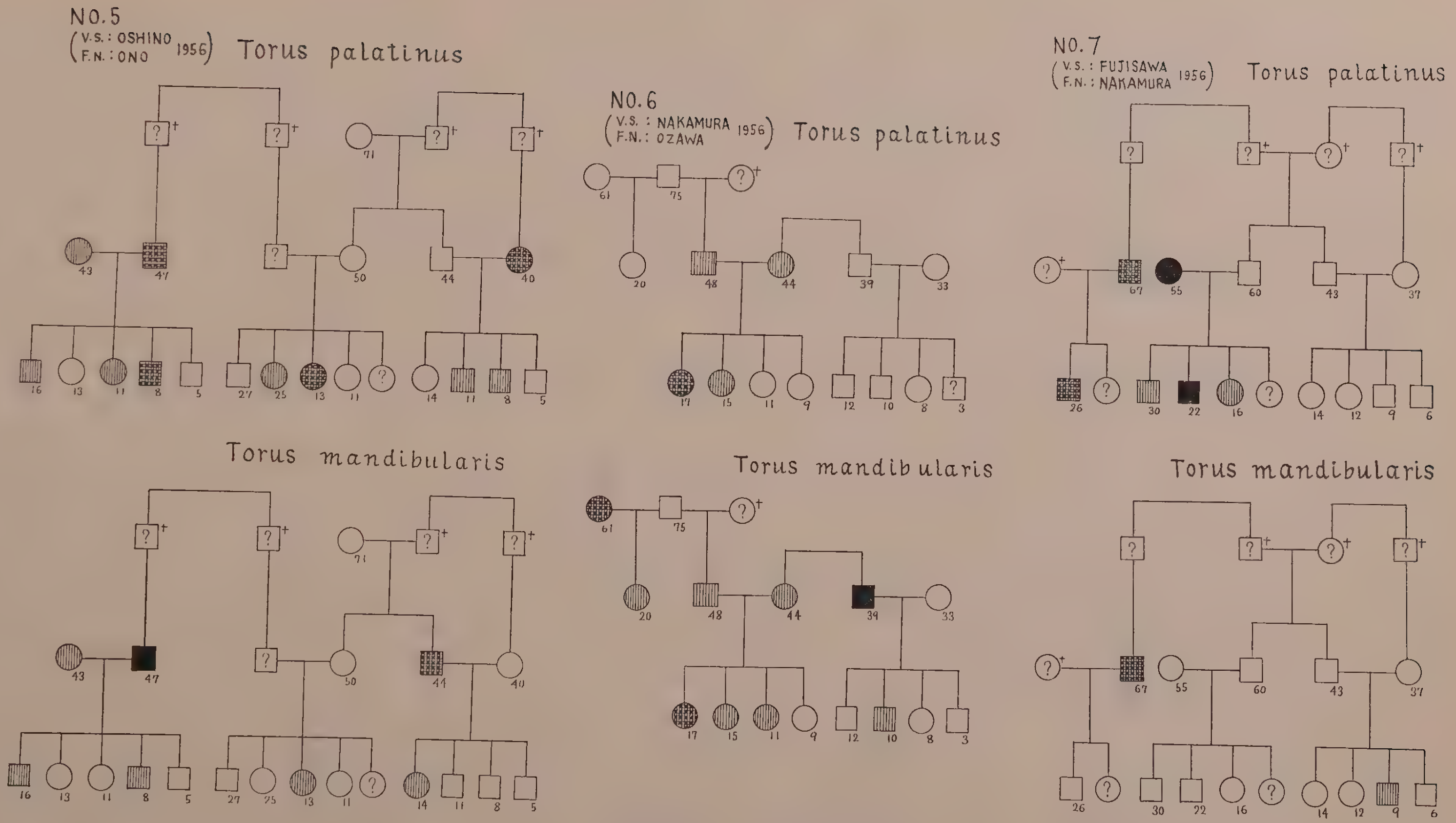


Figure 4



Figures 5, 6 and 7

he Concept of Homology Applied to the nterior Superior Iliac Spine[1]

ROBERT SHEERAN BENTON[2] AND JAMES ANDERSON GAVAN
*Department of Anatomy, Medical College of South Carolina,
Charleston, S. C.*

"When attention is concentrated on oints, rather than on anatomy, the points nay come to be regarded as independent hings." (Washburn, '42, p. 8). Washburn s discussing the problem of convincing hose who use osteological measurements or inter-species comparisons that, before neasurements are interpreted, the anatmy of associated soft parts should be nderstood. It is obvious from a perusal f anatomical textbooks that the skeleton s the reference for the decription of soft natomy. The muscular system is decribed in terms of the skeleton, but the keleton, according to Washburn, is to be nderstood in terms of the soft anatomy. t times this situation becomes overt: "As ar as osteological relations are concerned nese two spines (spina iliaca anterior et osterior superior) are homologous throughut the (primate) series; the posterior alvays marking the turning point between ne margo ischiadicus and the iliac crest; ne anterior, the turning point between the nargo acetabuli[3] and the iliac crest. *In espect to their relations to muscles, hower, the spines are not homologous."* Waterman, '28–'29, p. 612. Italics ours.) hus this author is willing to accept the omology of bony points but not the homolgy of muscular attachments.

The question arises: what should an inestigator rely upon as his basis for comarison? Should he use named bony points r attachment of soft parts? This question s basic in any comparison and is particurly so for historical interpretations. Our nderstanding of homologies must come rom comparative anatomy which is nonistorical in content. Once established, nese homologies can then be used for the nterpretation of the historical data of palentology. When this procedure is followed assiduously, the potential errors outlined by Simpson ('51) can be avoided.

As the situation now stands in primatology we have little basis for establishing clear cut homologies which can be used in historical thinking. With the recent increase in the number of primate fossil forms, the basic problem can only become more critical unless this confusion can be resolved.

It is the specific purpose of this paper to investigate the problem of homology as it relates to one named bony point: the spina iliaca anterior superior.

The confusion with respect to the spina iliaca anterior superior in comparative primate anatomy is easily illustrated by considering the attachments of the "inguinal" ligament. After considering this area in the rhesus monkey, Howell and Straus state "A true inguinal ligament is present only in man and gorilla" (p. 110 in Hartman and Straus, '33). Apparently there is no inguinal ligament in the monkey because the lateral, caudal, bony insertion of the M. obliquus externus abdominis is "upon the iliopectineal line near the pubo-

---

[1] This investigation was supported by research grants C-2663 from the National Cancer Institute and H-2417 from the National Heart Institute, U. S. Public Health Service.

[2] Present address: Department of Anatomy, University of Kentucky, Lexington, Kentucky.

[3] Anatomical terminology for the parts of the ilium is extremely sparse. The Nomina Anatomica, '55, contains only 19 terms under os ilium. The border referred to here as margo acetabuli is, in Morris' *Human Anatomy*, '53, called the anterior border, but as this border of the ilium would not be anterior in non-human primates, it would seem better to use a terminology independent of the human anatomical position. We will, therefore, follow Waterman and other primatologists and use the term margo acetabuli for that border of the ilium, furthest from the sacrum, which extends caudally from the crista iliaca.

iliac junction" (p. 107) rather than at the point identified as the anterior superior iliac spine (their fig. 22).

Speaking of the gorilla, Waterman ('28–'29, p. 617) states, "The anterior superior spine is truly homologous to that of man both in its osteological relationships and in its relations to muscles. There is a true Poupart's ligament attached at one end to the anterior superior spine and at the other to the anterior edge of the pubis." Thus, there is a true inguinal ligament because its bony attachments are the same as in man.

The opposite view can also be found. In describing the anatomy of the gorilla, Raven (in Gregory, '50, p. 56) states, "There is no thickening of the lower border of the aponeurosis (of the M. obliquus externus abdominis) to form an inguinal ligament." His description of the attachments of M. latissimus, M. sartorius, and M. obliquus externus abdominis would deny the homology of the point identified as anterior superior iliac spine with that of man. Curiously enough, the muscular attachments as illustrated in plates 58 and 59 (Gregory, '50) do not conform with the description given in the text.

A yes or no answer to this problem is not necessary. Ayer ('48), in his description of *Semnopithecus entellus*, finds that only one part of the "inguinal ligament" is homologous with that of man. This part does not involve either of the bony attachments.

This lack of agreement apparently arises from a failure to adhere to the principle which LeGros Clark calls "The Principle of Morphological Equivalence" ('55, p. 30). By assuming that points are homologous because they have the same name, the muscles appear to be attached in an unpredictable manner in the various primate forms.

MATERIAL

The following anatomical descriptions are based on the dissection of one juvenile female and two mature male rhesus monkeys (*Macaca mulatta*), one adult female *Pan chimpanzee*[4] and one sub-adult female *Pan paniscus*. Numerous photographs were made as the work progressed; all drawings have been prepared from these photographs.

The authors wish to express their sincer appreciation to the late Dr. Henry W. Nis sen, Director, and the rest of the staff o the Yerkes Laboratories of Primate Biology Inc. for the specimens of *Pan* as well a for the chimpanzee skeletal material whic they so generously provided.

Macaca mulatta

The drawings in figure 1 show the ven tro-medial and dorso-lateral surfaces of rhesus os coxae. The crista iliaca run ventro-laterally and then turning caudally continues as the margo acetabuli of the o ilium. In the ventro-medial view (fig. 1a the M. erector spinae and M. quadratu lumborum occupy most of the os ilium cra nial to the os sacrum and, therefore, the la bium internum as well. The fascia thora columbalis attaches to the crista iliaca, an the fusion of its dorsal and ventral lamell occurs near the lateral end of the crista From the dorso-lateral view (fig. 1b) it i evident that the labium externum define the cranial attachment of the M. gluteu medius. Both the M. iliacus and M. tenso fasciae latae are excluded from the crista also neither the M. obliquus externus no M. obliquus internus abdominis attach t it. The M. transversus abdominis has n attachment to the os ilium except for i most caudal fibers which, via the fasc thoracolumbalis, gain attachment at th point where the crista becomes the marg acetabuli. The M. latissimus, likewis gains attachment to the crista iliaca on via the fascia thoracolumbalis.

From the margo acetabuli there arise the M. tensor fasciae latae, M. sartoriu M. obliquus internus abdominis, and a aponeurosis which is related to the M. o liquus externus abdominis. The M. tenso fasciae latae has an extensive origin fro the margo acetabuli. Its origin begins ju caudal to the most cranial point on th margo acetabuli and extends caudally t overlap laterally the origin of the M. sa torius. Thus, the origin of M. tensor fa ciae latae separates M. gluteus mediu from M. sartorius (fig. 1a and b).

The M. sartorius has an extensive origi from the middle third of the margo acet

---

[4] We recognize only two species of chimpanze the pygmy chimpanzee, *Pan paniscus* of Coolid ('33) and *Pan chimpanzee* for all others.

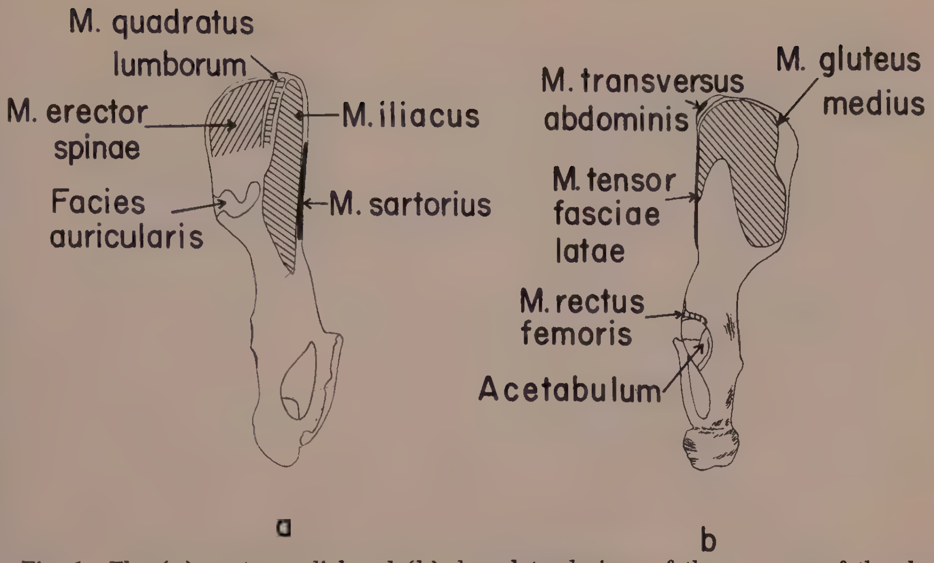


Fig. 1 The (a) ventro-medial and (b) dorso-lateral views of the os coxae of the rhesus monkey (*Macaca mulatta*).

buli. The most caudal portion of the margo acetabuli gives origin to a part of the M. rectus femoris, the rest of which has an origin adjacent to the cranial margin of the acetabulum. These parts are continuous and really constitute a single extensive origin (fig. 1b).

The M. obliquus externus abdominis gains an extensive attachment to the margo acetabuli via an aponeurosis. This aponeurosis is very dense from the most cranial point on the margo acetabuli to the cranial point of attachment of the M. sartorius. In the region of the M. sartorius attachment, it thins out somewhat only to become thick again caudally to form the lateral attachment of the crural arch. This crural arch extends medially over the M. iliacus, N. femoralis, A. femoralis, and V. femoralis to gain attachment to the os pubis (fig. 2).

The M. obliquus internus abdominis originates from the fascia thoracolumbalis and the margo acetabuli of the os ilium. The caudal one half of its iliac origin is aponeurotic as it arches over the M. iliopsoas. The most caudal fibers of the muscle originate from the deep face of the crural arch. They may continue to the fascia called iliaca in man and thus conform to the human picture as depicted by Keith ('33, p. 460) and McVay and Anson ('40). The crural arch is continuous with both the aponeurosis of the M. obliquus externus abdominis and with that fascia which immediately overlies the M. iliopsoas. Thus, this structure fulfills many of the requirements for an "inguinal ligament," but we prefer the terminology used by Gimbernat (1793) since this avoids the implications of the specialized anatomical condition found in man.

The N. cutaneus femoris lateralis pierces the aponeurosis of the M. obliquus externus abdominis medial to the origin of M. sartorius. It crosses the ventral border of this latter muscle on its course into the thigh (fig. 2).

Those structures, which in man arise from the crista iliaca between the spina iliaca anterior superior and the origin of the M. quadratus lumborum, arise in the monkey from the margo acetabuli of the os ilium.

Pan chimpanzee and Pan paniscus

The ventral, dorsal, and cranial aspects of a chimpanzee (Pan chimpanzee) os coxae are shown in figure 3. The ventral aspect (fig. 3a) of the ala ossis ilii is given over to the origin of the M. iliacus. The dorsal aspect (fig. 3b) gives rise to the M. gluteus medius and, to some extent, to the M. gluteus minimus.

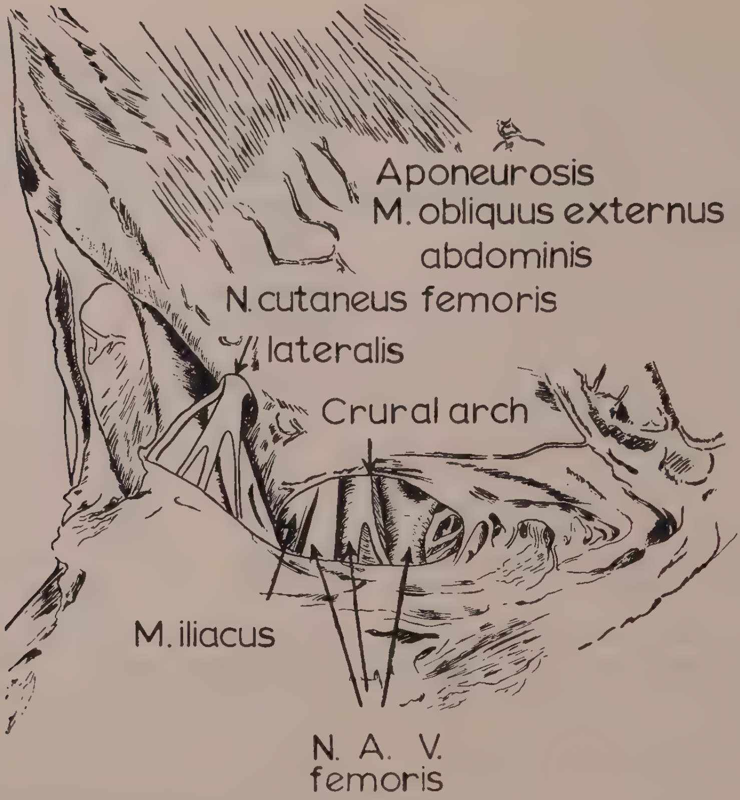


Fig. 2 The Crural Arch and associated structures of the rhesus monkey (*Macaca mulatta*).

The crista iliaca (fig. 3c) is quite thick medially and tapers to a relatively thin edge laterally. The edge itself runs in a medio-lateral direction. In its thicker medial third it gives origin to the M. erector spinae; directly adjacent laterally is the origin of the M. quadratus lumborum. The lateral one-half gives origin to a portion of M. latissimus, M. obliquus internus abdominis and M. transversus abdominis. The M. obliquus externus abdominis, M. tensor fasciae latae, and M. sartorius are excluded from the crista iliaca.

The M. latissimus arises from the labium externum of the lateral one-half of the crista iliaca. In *P. chimpanzee* its origin extends beyond the crista, see below; in *P. paniscus* M. latissimus is restricted to the crista.

The M. obliquus internus abdominis, which lies immediately deep to M. latissimus, has an origin which overlaps M. quadratus lumborum medially and extends la
erally the entire length of the crista. Thi
part of M. obliquus internus abdominu
runs cranio-laterally (due to the orienta
tion of the chimpanzee os ilium) to inse
on the most caudal rib. The origin of M
transversus abdominis on the crista iliac
extends from M. quadratus lumborum t
the most lateral point on the crista (fig. 3c

The key structure on the margo ace
abuli of the os ilium is a heavy aponeuros
which is attached to the length of th
margo acetabuli from its most crani
point to the caudal border of the origin c
M. sartorius (fig. 3a). This aponeurosis
in some way related to every muscle i
the region. Figure 4 shows the aponeur
sis with M. gluteus medius, M. glute
minimus, and M. tensor fasciae latae r
moved. As indicated above, in *P. chim*
panzee the most lateral portion of M. lati
simus extends beyond the crista, and no

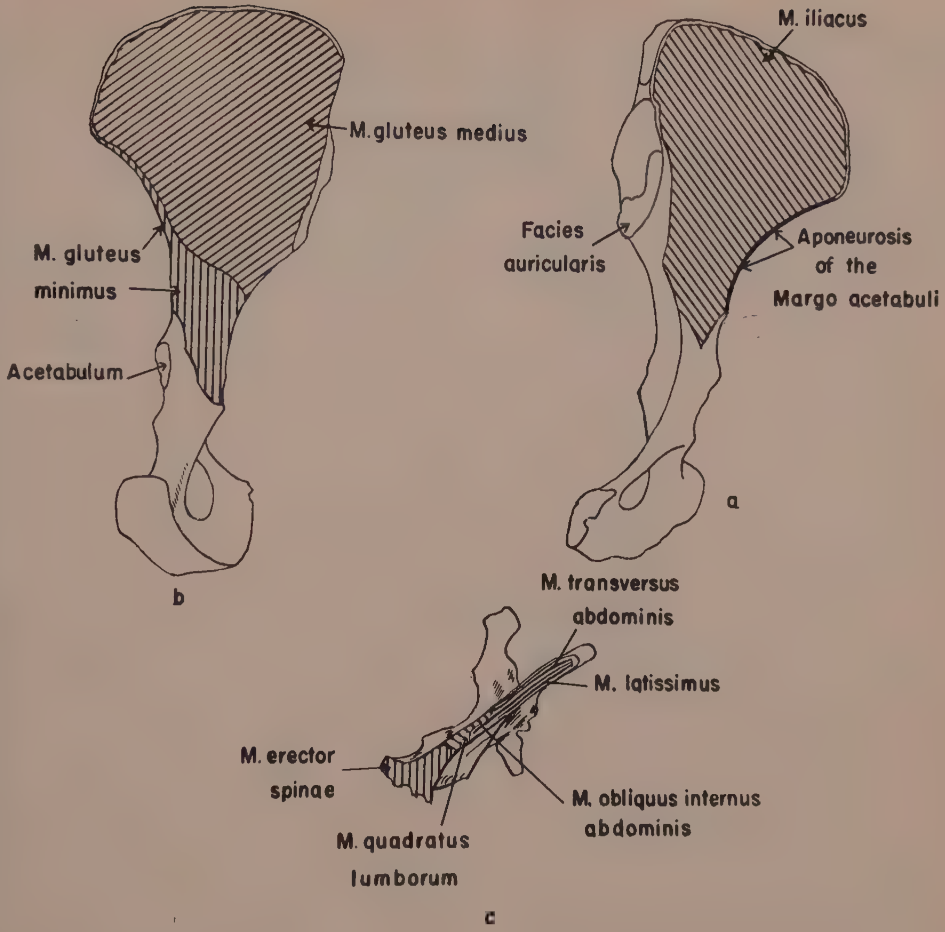


Fig. 3 The (a) ventral, (b) dorsal, and (c) cranial aspects of the os coxae of *Pan chimpanzee.*

it is seen to anchor in the cranial portion of this aponeurosis. Both M. transversus abdominis and M. obliquus internus abdominis take origin from this aponeurosis. The most dorsal part of the M. obliquus externus abdominis takes origin from the tip of the most caudal rib and extends caudally, missing the crista iliaca, to fuse with the aponeurosis of the margo acetabuli. The more ventral portions of the aponeurosis of the M. obliquus externus abdominis extend caudally to form the crural arch. This arch is anchored medially on the os pubis and laterally into the aponeurosis of the margo acetabuli along with the origin of M. sartorius. With this latter muscle the crural arch forms a reinforced, caudal margin to the aponeurosis of the margo acetabuli (fig. 4).

From the dorsal aspect of this aponeurosis the M. tensor fasciae latae, M. gluteus medius, and M. gluteus minimus take partial origin. From its ventral aspect some fibers of M. iliacus take origin.

The N. cutaneous femoris lateralis in both species of champanzee was found to emerge from the aponeurosis of the M. obliquus externus abdominis much as in the rhesus monkey: near the origin of M. sartorius and the lateral point of fixation of the crural arch (fig. 4).

The aponeurosis of the margo acetabuli of the os ilium functions as a latero-ventral

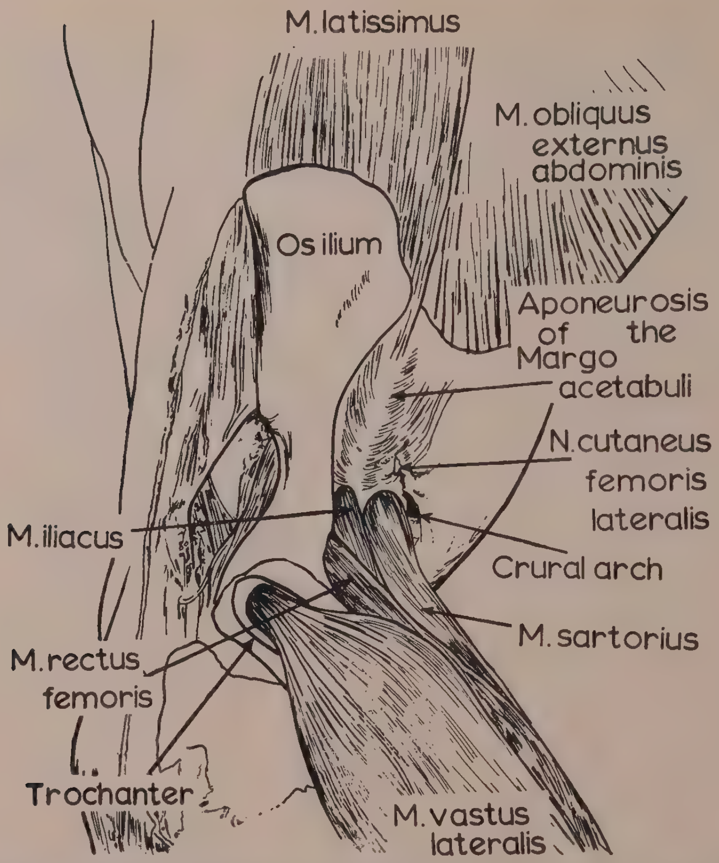


Fig. 4 The aponeurosis of the margo acetabuli in *Pan chimpanzee*. M. gluteus medius, M. gluteus minimus, and M. tensor fasciae latae have been removed.

extension of the ala ossis ilii in chimpanzee.

DISCUSSION

There are certain anatomical similarities between the rhesus monkey and the two species of chimpanzee; there are certain differences between these non-human primates as a group and man. In these non-human primates the aponeurosis of the M. obliquus externus abdominis gains either a direct or an indirect attachment to the margo acetabuli of the os ilium rather than to the crista iliaca as it does in man. In these non-human primates and in man there is a close association of the lateral point of fixation of the crural arch, the origin of M. sartorius, and the point at which the N. cutaneus femoris lateralis pierces the aponeurosis of the M. obliquus externus abdominis. The point to be noticed particularly is that these soft parts as a group are not associated with the same landmarks of the underlying os coxae. In these non-human primates, the associated soft parts lie on the margo acetabuli of the os ilium, cranial to the acetabulum but caudal to the point at which the crista iliaca becomes the margo acetabuli. In man the associated soft parts lie at the point where the crista iliaca becomes the anterior border of the ilium.

Thus, the soft parts hold together as a unit with a fairly constant relation in all three forms (rhesus, chimpanzee, and man). However, the relation of this complex to the crista iliaca differs between the non-human and the human primates.

Although we agree with LeGros Clark's principle of Morphological Equivalence, this paper raises the question of just how does one identify structures which are morphologically equivalent. Miller ('47, p. 139) takes an unequivocal position when she says, "In primates other than man there is no true inguinal ligament, its absence being correlated with the relatively much greater distance between the anterior superior iliac spine and the pubic symphysis." LeGros Clark appears to sanction such homology when, in discussing the os coxae of the australopithecinae and *Homo*, he says ". . . the region of the anterior superior spine extends farther forward . . ." ('55, p. 152).

In the field of paleontology the establishment of morphological equivalences must be particularly difficult. For there, of the bone-soft tissue complex, only bone remains. If comparative anatomy indicates a close correlation of soft parts but not a close association of soft parts with named bony points, how can one use these bony points to hypothecate taxonomic relations? It would seem that it is safe to assume that all bony points are not equally useful for inter-species comparisons. A necessary preliminary to such a procedure would appear to be a critical analysis of the bone-soft tissue complex.

SUMMARY AND CONCLUSIONS

The bone-soft tissue complex in the region of the crista iliaca and the margo acetabuli of the os ilium has been examined in *Macaca mulatta, Pan chimpanzee,* and *Pan paniscus*. It was the purpose of this examination to investigate the concept of homology as it applies to the spina iliaca anterior superior.

It was found that the soft tissues formed a complex, the parts of which showed a fairly constant relation to each other in these non-human primates and in man. The complex as a whole differed in its relation to associated bony parts.

It is concluded that named bony points cannot be considered homologous unless it can be shown that the entire bone-soft tissue complex is consistent in the forms compared.

LITERATURE CITED

Ayer, A. A. 1948 The Anatomy of Semnopithecus entellus. Indian Publishing House, Ltd., Madras.

Clark, W. E. LeGros 1955 The Fossil Evidence of Human Evolution. University of Chicago Press, Chicago.

Coolidge, H. J., Jr. 1933 *Pan paniscus*. Pigmy chimpanzee from south of the Congo River. Am. J. Phys. Anthrop., *18:* 1–59.

Gimbernat, A. de 1793 Nuevo mitodo de operar en la hernia crural. (English translation by T. Beddoes, London, 1795).

Gregory, W. K. (ed.) 1950 The Anatomy of the Gorilla. (Raven Memorial Volume). Columbia University Press, New York.

Hartman, C. G., and W. L. Straus, Jr. 1933 The Anatomy of the Rhesus Monkey. Williams and Wilkins Co., Baltimore.

Keith, A. 1933 Human Embryology and Morphology, 5th ed. W. Woods and Co., Baltimore.

McVay, C. B., and B. J. Anson 1940 Aponeurotic and fascial continuities in the abdomen, pelvis, and thigh. Anat. Rec., *76:* 213–232.

Miller, R. A. 1947 The inguinal canal of the primates. Am. J. Anat., *80:* 117–142.

Simpson, G. G. 1951 Some principles of historical biology bearing on human origins. Cold Spring Harbor Symposium on Quantitative Biology, *15:* 55–66.

Washburn, S. L. 1942 Technique in Primatology. Anthropological Briefs, *1:* 6–12.

Waterman, H. C. 1928–29 Studies on the evolution of the pelvis of man and other primates. Bull. Am. Mus. Nat. Hist., *58:* 585–642.

A Functional Approach to Craniology

MELVIN L. MOSS[1] AND RICHARD W. YOUNG[2]
Department of Anatomy, College of Physicians and Surgeons,
Columbia University, New York, New York

Craniology has been of considerable nterest throughout the history of physical nthropology. As a result, an enormous umber of cranial measurements have een accumulated. Nevertheless, concise tatements regarding the *significance* of his material are scarce. For example, vhat is the *biological meaning* of an inrease in cephalic index or a decrease in row ridging, of early or later closure of ranial sutures, or of changes in cranial apacity? The authors believe that a retatement of the general principles of funcional anatomical analysis will be useful n the further development of craniology.

This paper presents a functional anaomical analysis of 4 topics of craniological nterest: (1) neurocranial growth, (2) alvarial sutures, (3) supraorbital ridges, 4) the components of a calvarial bone. t is shown that: (1) the development of eurocranial form, both normal and abormal, occurs within an interacting funcional matrix consisting of the cerebral apsule, skull base and meninges. While he neural mass provides the magnitude f the neurocranial growth vectors their irection is determined by the maturing kull base and meninges. Cerebral form s the resultant of these forces; (2) sutural ocation, morphology and patency also relect the functional matrix within which hey exist; (3) the presence or absence f supraorbital ridges is only a reflection f the spatial relationship between two unctionally unrelated cephalic compoents, the orbit and the brain case, both f which are served by the frontal bone; nd (4) in even such a simple unit as the rontal bone the external and internal ables, as well as the diploe, respond to iffering functional demands.

Functional cranial components

The form of the skull is related to its *unctions.* All bones primarily *serve to protect and support soft tissues.* The skull arises and matures as part of a functional complex of tissues, brain, orbital contents, muscles, meninges, tongue, teeth: oral, nasal and pharyngeal cavities. Cranial form closely reflects the functional demands of these soft tissues throughout life. It is useful to think of the skull as comprised of a number of *functional components* associated with particular soft parts.

For this concept we are indebted to van der Klaauw ('46), whose dynamic hypothesis revitalized the study of cranial form. Van der Klaauw ('48–'52) proposed that: ". . . the skull may be regarded as a complex of relatively separate functional components, sometimes detached, sometimes united in a morphological whole, but even in this case to a certain extent independent in size, relative position and grouping." Functional cranial components are not to be confused with isolated morphological entities, such as individual bones. While a single bone may form a functional component in itself, these components may also include several bones or only portions of a single bone.

For example, we may grossly divide the skull into "neural" and "facial" components, which separately respond to neural and visceral functions. Or, for a more detailed analysis, we may break down the neural skull still further into functional components such as cerebral capsule, ear capsule, nasal capsule, orbit, etc. (van der Klaauw, '48–'52). Additionally, within a given calvarial bone we may differentiate three functionally independent components: an outer table, a diploe, and an inner table.

---

[1] Aided, in part, by grant B-965 (C3) and A-1930, National Institutes of Health.

[2] Predoctoral Fellow MF-6409 National Institutes of Health. Present address, Department of Anatomy, U.C.L.A., School of Medicine.

Studies dealing with many vertebrate forms, including the primates, have provided substantial support for these principles (Barnikol, '52; Hofer, '52, '54a, '54b, '54c, '58; Kummer, '52; Lang, '52, Starck, '53; Simon, '54; Scott, '55; Biegert, '57). They have also furnished working hypotheses for a series of laboratory experiments, as well as inquiries into the mechanisms of pathological and cultural cephalic malformations (Moss, '57a, '57b, '58a, '58b, '59a, '59b, '60; Young, '58, '59b).

(A) Functional analysis of neurocranial growth

The cerebral capsule is formed by the tissues which surround, and are intimately responsive to the functional demands of, the neural mass. In the fetus, the capsule includes the *entire* complex of soft tissues above and around the brain, and it is totally responsive to the spatial demands of the growing neural mass.

The brain normally comprises the greater part of the neural mass, but this need not be the case. Even when the cerebrum is virtually absent, the vault may appear to have a normal size and shape, if the cerebral capsule has become filled with an equivalent amount of fluid (i.e., hydranencephaly) (Minckler, McCurdy and Iwerson, '41; Johnson et al., '51). As development proceeds, the various layers of scalp, bone and dura are differentiated within the cerebral capsule (see below).

Differentiation of the dural fiber systems divides the calvarial surface of the capsule into a number of "fields." Approximately at the center of these fields ossification begins—in regions which have been variously termed "pressure poles" (Thoma, '11) or "loosened zones" (Graumann, '51). Bone differentiates in the capsular tissues immediately above the dural layer, and in this layer the bony trabeculae expand radially outward from the ossification center (Noback, '43).

This osseous expansion occurs by transformation of previously undifferentiated connective tissue cells into osteoblasts. Growth in length and height occurs at different *absolute* yet *relatively* constant rates (Moss and Baer, '56; Moss, Noback and Robertson, '56), while the entire ca sule continues to enlarge at a rate *dete mined* by the expansion of its conten (Noback and Moss, '56) (fig. 1). Th parietal bone, for example is *passive* carried outwards by capsular expansio while it is growing. The growth of th parietal itself has nothing to do with i relocation in space during this period development. Through this early enlarg ment, the parietal is merely ossifying portion of the cerebral capsule.

The outer layer of cranial dura is th inner periosteal layer of the calvari bones. Consequently, both *the size an shape of the inner surface of the osseo cranial vault is determined by the for of the dura, which in turn is a direct r flection of the form of the brain.* In mar mals which remain thin-skulled an small-muscled through maturity (such the rat and man) the size and shape the *entire capsule* may largely depen upon that of the neural mass.

By means of experimental hydrocep alus and microcephalus in rats, Youn ('58, unpublished) investigated the rel tionship between volume of cranial co

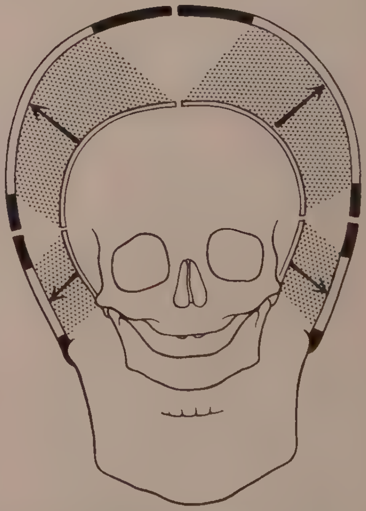


Fig. 1 The early expansive growth of t human neurocranium increases the size of t cerebral capsule and passively carries the e closed calvarial bones outward. The osteogene at the sutural areas (in black) is compensat to this expansion and tends to keep the sutu areas intact. It is by this process that t calvarial bones ossify successively larger are of the cerebral capsule.

ents and condition of the cerebral capsule. Vhen capsular contents were increased by ntraventricular accumulation of cerebro-pinal fluid, the capsule was correspond-ngly enlarged. The individual calvarial ones ultimately covered a larger area than sual. In the microcephalic animals, re-noval of portions of brain shortly after irth decreased cranial contents, resulting n the maturation of an appropriately maller capsule with smaller bones.

Size was not the only affected variable. Vhen intracranial contents were in-reased, the capsule and its individual ones assumed a more globular shape. Vhen contents were decreased, these tructures were flattened out over the de-cient brain.

Significantly, in these experiments com-onents of the *facial* skeleton, such as the asal bones, were not affected by these al-erations in the *cerebral* capsule. With re-ard to the base, the essentially plane rela-onships of midline structures were not isturbed, but the cerebral fossae were cor-espondingly larger or smaller. A current udy of micro- and macrocrania in man Young, '59b) shows that the same prin-iples are operative in the postnatal devel-pment of the human skull.

As the rate of brain growth lessens, the bsolute rate of capsular expansion corre-pondingly decreases, while the constancy f the relative growth rates of individual ones is retained (Noback and Moss, '56). eanwhile, ossification decelerates less apidly, so that the edges of adjacent bones rogressively encroach upon the interven-ng soft tissues of the presumptive sutures ntil they closely approximate each other. he mode of bone growth then alters, ith surface apposition by osteoblastic yers becoming predominant, producing thicker bone. Thus the area attained by e *individual bones within the capsule* epends upon the location of their ossifica-on center, and the duration and rate of eripheral osseous deposition.

The expansion of the enclosed neural ass provides the *magnitude* of the neural rowth vectors. The *direction* of these me vectors, on the other hand, is deter-ined primarily by preferentially oriented er tracts of the dura mater (Bluntschli, 5, and others). The functional unity of base, brain, vault and dura has been described by a number of authors (Bluntschli, '25; Hochstetter, '39, Kokott, '33; Popa, '36; Witzig, '40; and esp. Deggeler, '42). It is quite proper to regard the dura as the unossified part of the cerebral capsule, or conversely to regard the bone as the ossified part. The extent of this process in mammals is variable, as indicated by the ossification of the tentorium cerebelli in the cat.

From its inception the cerebral capsule is "tied down" to the originally cartilagenous cranial base at 5 points: the crista galli, the lesser wings of the sphenoid, and the petrous crests of the temporal bone (fig. 2). Oriented fiber systems appear very early within the capsule in association with the sites of basal attachment. They are found (in what will become the adult dura mater) running from the crista galli, in the falx cerebri, from the lesser sphenoidal wings and from the petrous crests, in the tentorium cerebelli, in bundles which sweep up over the brain (for details see Popa, '36). In the adult the chief fiber tracts underlie the major calvarial sutural sutures, the anterior lateral varial sutural areas—the midline system

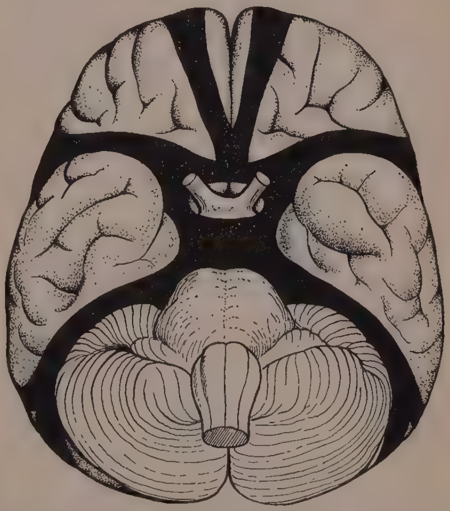


Fig. 2 A basal view of the adult human brain. The areas in black represent the chief organized tracts of dural fibers as they arise from their attachments to the skull base in the region of the sella turcica. The anterior, middle and posterior pairs underlie the sagittal, coronal and lambdoidal sutural areas respectively (after Popa, '36).

under the sagittal and metopic sutures, the anterior lateral system under the coronal suture and the posterior lateral system under the lambdoidal suture.

The characteristic form (i.e., size and shape) of the normal neural skull is the resultant of the preferential direction of the growth vectors of the expanding neural mass by these dural fiber systems.

As the internal vectors of normal cranial growth influence the development of neurocranial form, so in premature cranial synostosis an early, *primary*, spatial malformation of the points of basal dural attachment alters the direction of neural growth vectors and results in secondary compensatory adjustments of the neural skull (Moss, '59a). Mechanical forces acting on the *outside* of the capsule may also influence its development in a reciprocal manner. Factors such as binding of the immature head (Moss, '59b) or maintenance of an habitual sleeping position (Young, '57, and esp. Moss, '59b) bring about primary alterations in the form of the frontal bone and other cephalic components which act through the dura mater to produce *secondary* basal malformations.

The common factor in each of these cases is a mechanical condition which limits the expansion of the capsule in certain directions by diverting the direction of growth vectors ultimately attributable to the neural mass. Since the magnitude of neural growth is unaffected in both cases, a change in form of the cerebral capsule results.

(B) Functional analysis of cranial sutural areas

We have emphasized that the calvarial bones must be considered as existing within the functional matrix of tissues within which it developed. The same principles hold true for the calvarial sutures, for these too are far from self-regulating in their development. A suture is a remnant of the originally membranous cerebral capsule. As a localized region within the cranial capsule, it shares with the calvarial bones a similar functional matrix.

The soft tissues between two adjacent calvarial bones is a *suture*. When the immediately adjoining bony edges are included, we deal with a *sutural area*. A
suture has several functions: it resists th
separation of bones; and it allows relativ
motion between them (Moss, '57a). R
cent experimental data, considered from
functional viewpoint, have clarified man
problems relating to sutures.

1. The shape of a calvarial bone is n
predetermined by the location of the su
tures. It is possible to experimentally di
place sutural position. The location of
suture is determined by the relative growt
of adjacent bones (Moss, '54; Girgis an
Pritchard, '58) as indicated above, page
282 and 283.

2. The neurocranial sutures are *n*
growth sites in *any* sense analagous to a
epiphysis. They do not "push the bone
apart." The sutural area is a site whe
bone may be added to *compensate* for th
separation of bones which occurs as th
cerebral capsule expands and passivel
carries the bones outward (fig. 2). As
result, extirpation of sutures in growin
animals is not followed by alteration i
overall dimension of the cranium (Mos
'54).

3. The intrinsic morphology of all ca
varial sutural areas freed from norma
functional demands is flat, butt-end artic
lation. Both beveling and interdigitatio
are responses to extrinsic forces whic
normally are operative when the bones a
in their functional matrix (Moss, '57a).

4. Adjacent cranial bones cannot b
made to fuse simple by pressing the
against each other (Laitinen, '56; Mos
'57a; Young, unpublished); there are mo
factors involved in synostosis than me
proximity of bone edges. Actually, sutur
fusion is an event *usually* mediated by e
trinsic forces. It does not occur when th
bones are removed from their normal fun
tional matrix (Moss, '58b). The extern
forces appear to act through the fibro
structures of the neurocranial capsule. I
the rat, for example, the normal end
cranial fusion of the posterior portion
the frontal (metopic) suture is well cor
lated with the structural alterations
the falx cerebri which accompany the r
tation of the facial skull relative to t
neural skull (Moss, '58b). This has bee
further confirmed by the inhibition of f
sion following experimental separation
the falx from the overlying suture (Mos

0). In premature sutural fusion in man milar dural changes have been postu- ted to arise as a result of malformations the skull base (Moss, '57b; '59a). Evi- ently alterations in the cranial base odify mechanical conditions within the apsule; resulting abnormal tensile forces e transmitted to the vault through the ural fiber systems and seemingly induce nostosis. Finally, we have preliminary dications that the time sequences of su- ural maturation and fusion may be altered y varying the amount of intracranial con- nts (Young, unpublished).

It is quite clear that a proper functional onsideration of such a morphologically mple thing as a suture cannot be correct the suture *alone* is studied. The calvarial itures and bones exist in a functional atrix which includes dura, neural tissues, paces and muscles. Their morphology eflects the varying functional needs of is matrix.

C) *Functional analysis of the supraorbital ridge*

The frontal bone not only contributes to e cerebral capsule, it also forms part of e orbit. Thus the functional demands of vo independent cranial components are et simultaneously by the same bone. In e human braincase, the inner table of e frontal bone is functionally associated ith the development of the frontal lobe of e cerebral cortex. Superiorly and later- lly it forms the anterior portion of the ner surface of the calvaria. Inferiorly furnishes the lateral portions of the oor of the anterior cerebral fossa, which *simultaneously* the roof of the orbit. The orm of the frontal bone in this latter re- ion accurately reflects the functionally ariable spatial relationships between orbit nd braincase. With an increased separa- on of these functional components during rowth, the orbital roof becomes thicker nd an invasive pneumatization from ad- acent sinuses may even occur (fig. 3).

At birth, the human ocular globe is only artially covered superiorly by the frontal one. With increasing age, it becomes en- osed to a much greater extent (fig. 4), s surrounding bones respond to the rowth of the ocular mass by providing in- eased support and protection for these soft tissues. Experimental investigations in non-human forms have demonstrated that growth of the bony orbit is highly responsive to the development of enclosed soft tissues (Wessely, '20; Washburn and Detwiler, '43; Coloumbre and Crelin, '58). Similarly, infantile enucleation in man results in diminished orbital size (Taylor, '39).

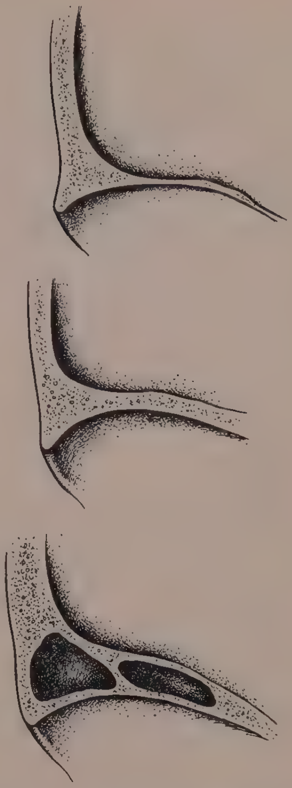


Fig. 3 Three normal vertical variations in spatial relationship in man between the anterior cerebral fossa and the orbit are shown. As separation increases, the orbital roof first thickens and then pneumatizes (after Whitnall, S. E. 1921 The Anatomy of the Human Orbit, London, Frowde, Hodder and Staughton).

The role of the frontal bone in providing an adequate orbital roof is *independent* of its contribution to the cerebral capsule. In man the cerebral mass overlaps the orbit, and the normal growth rates of orbital and cranial contents result in a fairly constant antero-posterior spatial orientation between them. Furthermore, growth of orbital and cerebral masses ceases at about the same age (4 years).

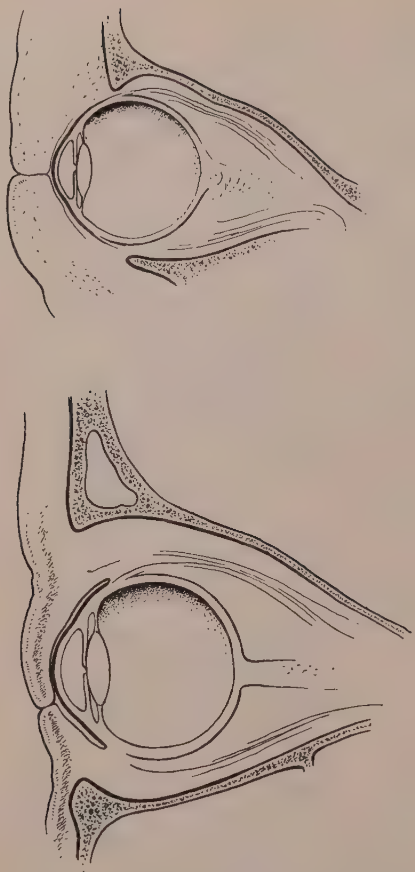


Fig. 4 The horizontal anterior growth of the human bony orbit is shown. At birth (above) about half of the globe is anterior to the orbit while in the adult (below) the globe is almost completely covered (after Whitnall, '21).

However, when there is a *smaller* cerebral volume with *normal* orbital contents, the independence of both components becomes apparent. In human microcephaly, the frontal lobes no longer completely overlie the orbit, due to the decrease in neural mass. The portion of the frontal bone functionally related to the *brain* adapts itself to the smaller neural mass by processes outlined above. The portion of the frontal bone functionally related to the *orbit*, however, continues to surround the normal volume of orbital contents. It grows forward over the globe as usual. A large *supraorbital ridge* is the morphological result of these two growth processes (fig. 5).

We agree with Abbie ('52) that a fun tional correlation between brow ridgin and jaw size (Toldt, '14; Bolk, '22; Wei mann and Sicher, '55) is unjustified. Fi ure 6 compares the orang and gorilla, bot of which have relatively massive jaw The presence or absence of appreciab supraorbital ridges in these forms is clear related to the spatial relationship betwee the orbit and braincase alone. In the new born of both forms the orbit is well ove lapped superiorly by the braincase, an no supraorbital ridge is seen. In the adult this relationship is only partially modifie in the orang, while in the gorilla a wid separation of the two functional comp nents occurs (Biegert, '57). This displac ment is influenced by a greater bendin (kyphosis) of the splanchocranium rel tive to the neurocranium in the gorill carrying the face and orbit down an forward from the neural skull (see Delatt and Fenart, '56, for details). As a neces sary, functional consequence of the separ tion between braincase and orbit, a bro ridge is formed in the gorilla alone. homologous situation has been clear demonstrated in the dog (Weidenreic '41).

The same principles may be applied in i terpreting the significance of frontal bon morphology in early hominid forms. Th site and magnitude of postorbital constri tion, for example, depends upon the rel tive size and spatial relations of orbit contents and brain (Mollison, '25; Stad müller, '49). Brow ridges, as suggeste above, may be similarly explained (fig. 7 As a correlate to the increase in brain si characteristic of human evolution, th cerebrum covers the orbit more complete As a result, changes occur in the form the frontal bone, since it continues to r spond to the functional needs of bo neural and orbital soft tissues. In mode man, the normal ontogenetic expansion the cerebral frontal lobe brings the bra into the region where a brow ridge fo merly appeared. Consequently, the po tion of the frontal bone responsive to th neural mass is displaced anteriorly, whe it blends smoothly with the superior orbit margin. We conclude, then, that the si nificance of the phylogenetic disappea ance of hominid brow ridges is found

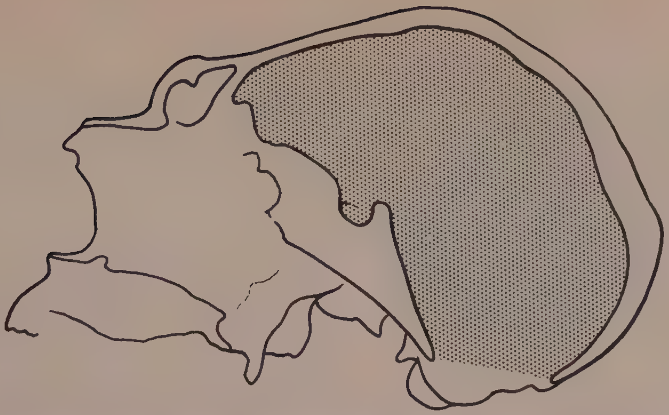


Fig. 5 A lateral tracing of an adult microcephalic skull. Note the deficient cerebral frontal mass and the large supraorbital ridge which covers a normally positioned globe. Compare with figures 6 and 7. (After Vogt, C. 1867 Über den Mikrocephalen oder Affen-Meschen. Arch. Anthrop., 2: 128–284).

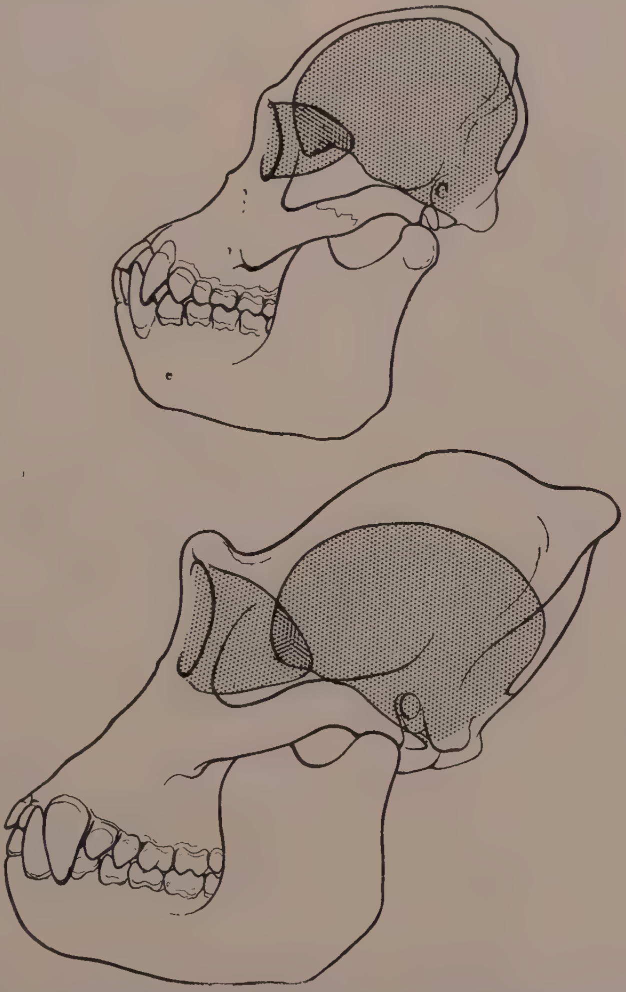


Fig. 6 Diagrams of lateral view of an adult male orang (above) and an adult male gorilla (below), showing the differing spatial relationships between their similarly sized brains and orbits. Note also the relative similarity of their jaw size. The presence of the supraorbital ridge in the gorilla seems closely related to the anterior position of the orbit in this form (after Biegert, '57). (Sagittal crest is schematically indicated).

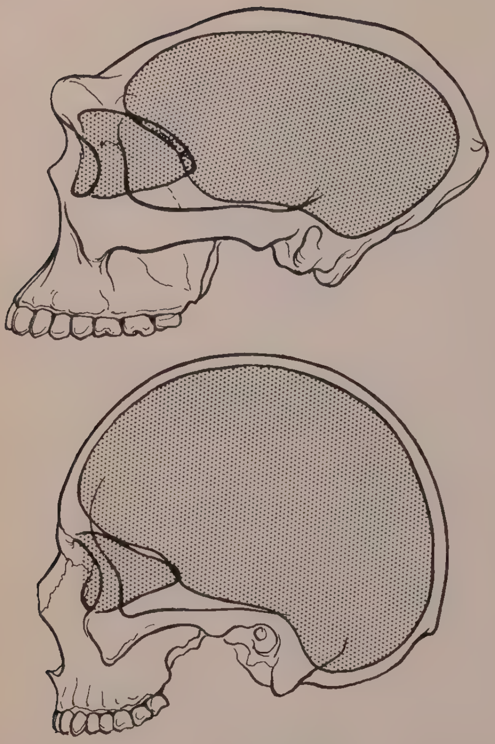


Fig. 7 A lateral representation of Pithecanthropus skull IV and of a skull of an adult male Austrian (A.M.N.H. no. 3813). Orbital outlines have been added. The supraorbital ridging of the former is related to the relative position of orbit and brain in precisely the same manner as shown in figures 5 and 6. (After Weidenreich, F. 1943 The skull of Sinanthropus pekinensis. Palaeontol. Sinica, n.s. *D10:* 1–298).

the changing relationships of associated soft tissues.

In common laboratory mammals (rat, guinea pig, rabbit) the calvarial portion of the frontal bone serves to protect two *different* functional components. In these forms the olfactory bulbs lie in the fossa olfactoria well anterior to the cerebrum, and are partially separated from it by an endocranial ridge (Jugum limitans fossae olfactorae, Simon, '54). In experimental hydrocephaly in the rat, compression of the olfactory lobe causes the ridge to be located farther forward, so that the cerebral part of the frontal is increased relative to the olfactory component. To compensate for this, inter-orbital distance is widened, and the olfactory portion of the frontal bulges upward (Young, unpublished). The cerebral and olfactory components of the ra frontal bone not only have different functions, growth rates and morphologies, eve their sutural patterns are dissimilar (Moss '58b).

(D) *Functional components within the frontal bone*

The adult human frontal bone, in common with all other calvarial bones, consist of an inner and outer plate of compac bone, and an intervening mass of trabecular bone, the diploe. Ontogenetically, th frontal bone begins as a mass of simpl trabeculae, which expand from the primary ossification centers in the form o simple radiating trabeculae. A centrifuga gradient of maturation of this bone into thicker, though still porous tissue mass i followed by the production of the definitive, three-layered structure (Bernstein '33; Noback, '43; Moss, '54). Prior to th formation of diploe and plates, the entir bone—indeed the entire cerebral capsule—is functionally related to the brain alone

Outer table. The gradual differentiation of the outer plate is correlated wit the increasing demands of the scalp tissues in general, and of calvarial muscle in particular. The result of this osseou differentiation is to *dissociate functionall* the two plates of bone with the appearanc of intervening diploe.

Numerous experiments have shown tha the influence of muscle function is essentially limited to the *outer* table (Fick, 1857 Anthony, '03; Neubauer, '25; Washburn '47). Cranial crests and ridges associate with muscle attachments are functionall related to these muscles for their development and continued existence (Washburn '47). Their location may vary, howeve with changes in the volume of materia enclosed by the cerebral capsule: the temporal lines, for example, are higher i microcephaly, lower in macrocephal (Riesenfeld, '55). When cranial content are deficient on one side only, the tempora lines are higher on that side (Young '59b).

Inner table. The inner table is exquisitely sensitive to alterations in cerebral morphology not only during the perio of brain growth, but throughout the lif span. The inner plate normally alters to a commodate the cerebral shrinkage which accompanies old age (Hartl and Burkhardt, '52). More dramatic is hyperostosis frontalis interna (Moore, '53), characterized by proliferation of the inner plate following severe shrinkage of the cerebral mass. Numerous examples of the intimate dependence of endocranial form upon the state of adjacent soft tissues are found in the clinical literature (cf. Dyke et al., '33; Ross, '41; Noetzel, '49; Fischgold and Metzger, '51; Lefebvre, '51; Lefebrvre et al., '53, '55; Kehrer, '55; Schiffer, '56; Schiffer and Korn, '56). A typical example is presented in figure 8.

Diploe. The diploe has several simultaneous functions, including hematopoiesis, for which it becomes increasingly important with advancing age. Concomitantly, weight reduction of total bone is gained by the increase in trabecular bone at the expense of compact bone. Pneumatization of the frontal sinus indicates that the diploe is also functionally responsive to the respiratory system. In any complete functional analysis of the skull, an empty space (nasal cavity, oral cavity, sinus) may be as much "soft tissue" as in muscle (see Moss, '59c for details of this hypothesis).

We may safely conclude that the form of the *ectocranial* surface of the neurocranium is functionally unrelated to that of the endocranial surface (Hofer, '54; Simon, '55). Similarly independent are postnatal variations in that part of the capsule which differentiates into scalp (Garn, Selby and Young, '54; Young, '59a).

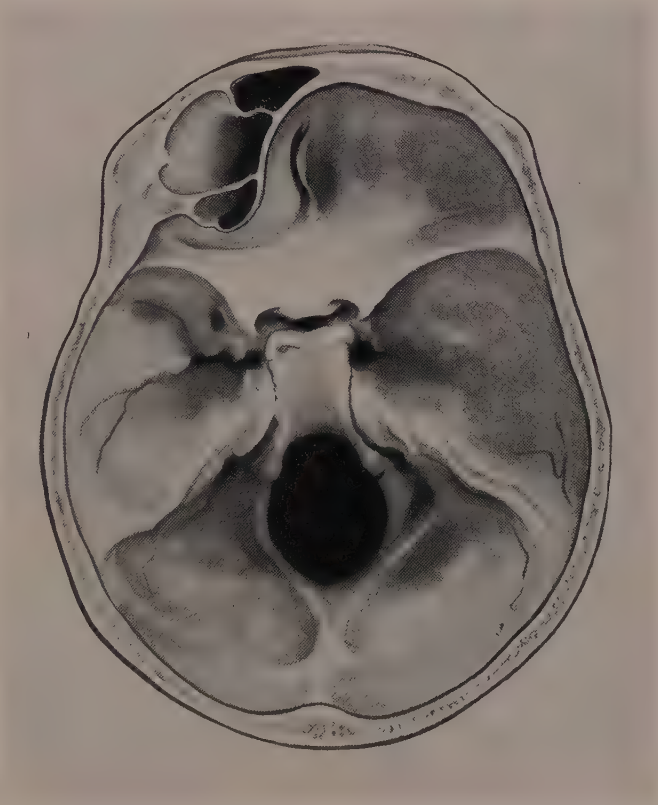


Fig. 8 An endocranial view of a human skull base. An extensive compensatory pneumatization and inward displacement of the left frontal endocranial plate has followed an atrophy of the left frontal cerebral lobe. Note that the outer plate of this bone is unaffected. (After Noetzel, '49).

DISCUSSION AND SUMMARY

The skull is made up of a number of *functional components*, which *support or protect related soft tissues.*

When the adult, human frontal bone was analyzed with this concept in mind, it became evident that this single morphological structure is by no means a single *functional* unit. The inner table is part of the cerebral capsule, a functional component which is highly responsive to the requirements or intracranial soft tissues *at all times.* The outer table, however, is functionally independent. Anteriorly and inferiorly its form is associated with the support and protection of soft tissues in another functional component, the orbit. Elsewhere it may be locally modified by forces due to muscle action. The middle osseous layer, the diploe, is also functionally independent, being concerned with hematopoiesis, and with pneumatization by respiratory sinuses. Finally, even the frontal suture is far from being a simple, intrinsically regulated entity. It is greatly influenced by related soft tissues, dura and cranial base, and cannot adequately be studied in isolation from them.

In other words, the form of the frontal bone is comprehensible only when the normal *functional matrix* of the bone is taken into account. This means that one must consider brain, cerebrospinal fluid, orbital contents, sinuses, muscles and other soft tissues in order to understand the determination of form of even a single bone.

We believe that interpretation of craniolgical material will be enhanced if attention is paid to these principles.

It may be noted, for example, that length and width measurements which comprise the cranial index include all three, functionally independent layers of bone in two walls of the cerebral capsule, plus any contained soft tissues (or the cavity which they formerly occupied). If the measurements are made over intact scalp, a further variable is added. Furthermore, the length dimension includes elements of two overlapping skull components, braincase and orbits. Nevertheless, insofar as the index gives a rough approximation of the proportions of the cerebral capsule—as it does in thin-skulled, small-muscled forms such as the rat and man—its significance is not entirely obscure. The form of the capsule in such a case is in large measure a result of the development of intracranial soft tissues. Brachycephaly for example, must ultimately reflect changes in intracranial tissues—not upright posture, growth rates at sutures, or other previously suggested factors which have failed to relate the cranial bones to their proper functional matrix.

It is implicit in our hypothesis that ontogenetically the form of the osseous skull at any moment accurately reflects the resultant of the functional demands of the protected and supported soft tissues. An identical orientation may be given to phylogenetic considerations (see Biegert, '57) We may say that the obvious evolutionary changes in osseous form appear in reality to be secondary manifestations of primary changes in the related soft tissues. Evolutionary modifications in soft parts will bring about appropriate alterations in functionally related portions of the skull

The adoption by physical anthropologists of a functional approach to craniology should provide a sounder basis for the interpretation of craniological material than has previously existed.

LITERATURE CITED

Abbie, A. A. 1952 A new approach to the problem of human evolution. Trans. Roy. Soc. S Aust., *75:* 70–88.

Anthony, R. 1903 Introduction à l'etude experimentale de la morphogenie. Bull. Mem Soc. d'Anthrop., Paris, V. Ser., *4:* 119–145.

Barnikol, A. 1952 Korrelation in der Ausgesta tung der Schädelform bei Vögeln. Morph. Jb *92:* 373–414.

Bernstein, S. A. 1933 Über den normalen histologischen Aufbau der Schädeldachs. Zei Anat. Entwicklungs., *101:* 625–678.

Biegert, J. 1957 Der Formwandel des Primate schädels. Morph. Jb., *98:* 77–199.

Bluntschli, H. 1925 Zur Frage der functionelle Struktur und Bedeutung der harten Hirnhau Arch. Entw. Mech., *106:* 303–319.

Bolk, L. 1922 On the significance of the supraorbital ridges in primates. Proc. Kon. Apac Wetens, Amst. *25:* 16–21.

Coulombre, A. J., and E. S. Crelin 1958 Th role of the developing eye in the morph genesis of the avain skull. Am. J. Phys., An throp., *16:* 25–37.

Deggeler, C. 1942 Beitrag zur Kenntnis de Architektur des fetalen Schadels. Ztschr. Ana Entwicklungs., *111:* 470–489.

Delattre, A., and R. Fenart 1956 Analyse morphologique du splanchnocrane chez les primates et ses rapports avec le prognathisme. Mammalia, *20:* 168–323.

Dyke, C. G., L. M. Davidoff and C. B. Masson 1933 Cerebral hematrophy with homolateral hypertrophy of the skull and sinuses. Surg., Gyn. Obstet., *57:* 588–600.

Fick, L. 1857 Über die Ursachen der Knochenform. Göttingen. Cited by Weidenreich, 1941.

Fischgold, H., and J. Metzger 1951 Signes radiographiques discrets et precoces des atrophies cerebrales unilaterales. J. Radiol., *32:* 733–741.

Garn, S. M., S. Selby and R. W. Young 1954 Scalp thickness and the fat-loss theory of balding. A. M. A. Arch. Derm. Syphilol., *70:* 601–608.

Girgis, F. G., and J. J. Pritchard 1958 Effects of skull damage on the development of sutural patterns in the rat. J. Anat., *92:* 39–51.

Graumann, W. 1951 Topogenese der Bindegewebsknochen. Ztschr. Anat. Entwicklungs., *116:* 14–26.

Hartl, F., and L. Burkhardt 1952 Über Strukturumbau des Skelets, besonders des Schädeldachs und Schlüsselbeins, beim Erwachsenen und seine Beziehungen zur Hypophyse, nach Massgabe des spezifischen Gewichts und histologischen Befundes. Virchow's Arch., *322:* 503–528.

Hochstetter, F. 1939 Über diet Entwicklung und Differenzierung der Hüllen des menschlichen Gehirnes. Morph. Jb., *83:* 359–494.

Hofer, H. 1952 Der Gestandwandel des Schädels der Säugetiere und Vögel, mit Berücksichtigung der Knickungstypen und der Schädelbasis. Anat. Anz., *99:* 102–113.

——— 1954a Die cranio-cerebrale Topographie bei den Affen und ihre Bedeutung für die Menschliche Schädelform. Homo, *5:* 52–72.

——— 1954b Beobachtungen am Hirnrelief der Aussenfläche des Schädels, am Endokranium und der Hirnform des südamerikanischen Nachtaffen (Aotes, Ceboidea). Ber. Oberhess. Geselsch. Natur.-Heilkd. Giess. N. F. Naturwisse., *27:* 90–114.

——— 1954c Über die Falx cerebri der Affen, nebst einigen Bemerkungen uber Hirn und Schädel der Primaten. Morph. Jb., *94:* 275–334.

——— 1958 Vergleichende Beobachtungen über die Kraniocerebrale Topographie von Daubentonia madagascariensis. Ibid., *99:* 26–64.

Johnson, E. E., M. Warner and J. P. Simonds 1951 Total absence of the cerebral hemispheres. J. Pediat., *38:* 69–79.

Kehrer, H. E. 1955 Der Hydrocephalus Internus und Externus. Seine Klinische Diagnose und Therapie. Bibl. Psychiat. Neur., *94:* 1–190.

Klaauw, C. J. van der 1946 Cerebral skull and facial skull. Arch. Neerl. Zool., *7:* 16–37.

——— 1948–1952 Size and position of the functional components of the skull. Ibid., *9:* 1–559.

Kokott, W. 1933 Über den Bauplan des fötalen Hirnschädels. Morph. Jb., *72:* 341–361.

Kummer, B. 1952 Untersuchungen über die ontogenetische Entwicklung des menschlichen Schädelwinkels. Z. Morph. Anthrop., *43:* 331–360.

Lang, C. 1952 Über die Ontogenie der Knickungsverhältnisse beim Vogelschädel. Anat. Anz., *99:* 127–136.

Laitinen, L. 1956 Craniosynostosis. Ann. Paediat. Fenn., *2:* 1–130, Suppl. 6.

Lefebvre, M. 1951 Resultats obtenus à l'Hôpital des enfantsmalades au point de vue des atrophies cérébrales. J. Radiol., *32:* 741–743.

Lefebvre, J., C. Faure, J. Metzger and M. Mettier 1955 Action du cerveau sur le crane au cours des premieres annees de la vie. Ibid., *36:* 297–307.

Lefebvre, M., J. E. Guy and J. Metzger 1953 Evolution des signes radiographiques des atrophies cerebrales unilaterales. Acta Radiol., Stockholm, *40:* 314–324.

Minckler, J., T. McCurdy and J. C. Iwerson 1941 Hydranencephalus with cerebellar hemidysgenesis. Nebraska St. Med. J., *26:* 131–135.

Mollison, T. 1925 Über die Kopfform des mikrokephalen mesek. Z. Morph. Anthrop., *25:* 109–128.

Moore, S., A. M. Moore and J. B. Brown 1953 Crouzon's deformity with hyperostosis frontalis interna. Plastic and Reconstr. Surg., *12:* 1–9.

Moss, M. L. 1954 Growth of the calvaria in the rat. The determination of osseous morphology. Am. J. Anat., *94:* 333–362.

——— 1957a Experimental alteration of sutural area morphology. Anat. Rec., *127:* 569–589.

——— 1957b Premature synostosis of the frontal suture in the cleft palate skull. Plastic and Reconstr. Surg., *20:* 199–205.

——— 1958a Rotations of the cranial components in the growing rat and their experimental alteration. Acta Anat., *32:* 65–86.

——— 1958b Fusion of the frontal suture in the rat. Am. J. Anat., *102:* 141–165.

——— 1959a The pathogenesis of premature cranial synostosis in man. Acta Anat., *37:* 351–370.

——— 1959b The pathogenesis of artificial cranial deformation. Am. J. Phys. Anthrop., *16:* 269–286.

——— 1959c Disorders of the Temporomandibular Joint, by L. Schwartz, ed. W. B. Saunders Co., Philadelphia, chap. 6.

——— 1960 Inhibition and stimulation of sutural fusion in the rat calvaria. Anat. Rec., *136:* 457–468.

Moss, M. L., C. R. Noback and G. G. Robertson 1956 Growth of certain human fetal cranial bones. Am. J. Anat., *98:* 191–204.

Moss, M. L., and M. J. Baer 1956 Differential growth of the rat skull. Growth, *20:* 107–120.

Neubauer, G. 1925 Experimentelle Untersuchungen über die Beeinflussung der Schädelform. Z. Morph. Anthrop., *23:* 411–441.

Noback, C. R. 1943 Some gross structural and quantitative aspects of the development of the human embryonic, fetal and circumnatal skeleton. Anat. Rec., *87:* 29–51.

Noback, C. R., and M. L. Moss 1956 Differential growth of the human brain. J. Comp. Neur., *105:* 539–552.

Noetzel, H. 1949 Über den Einfluss des Gehirns auf die Form der benachbarten Nebenhöhlen des Schädels. Deutsche Z. Nervenheilkunde, *160:* 126–136.

Popa, G. T. 1936 Mechanostruktur und Mechanofunction der Dura mater des Menschen. Morph. Jb., *78:* 85–187.

Riesenfeld, A. 1955 The variability of the temporal lines, its causes and effects. Am. J. Phys. Anthrop., *13:* 599–620.

Ross, A. T. 1941 Cerebral hemiatrophy with compensatory homolateral hypertrophy of the skull and sinuses, and diminution of cranial volume. Am. J. Roentgenol., *45:* 332–341.

Schiffer, K. H. 1956 Zur Ableitung von Entwicklungsvorgängen aus dem Röntgenbild des Schädels. Acta Radiologica, *46:* 123–129.

Schiffer, K. H., and W. Korn 1956 Zur Frage der korrelativen Entwicklungsstörungen im Bereich des Mittelgesichts. Z. menschl. Vererb. Konstitutionslehre, *33:* 306–315.

Scott, J. H. 1955 Craniofacial regions. Dental Pract., *5:* 208–214.

Simon, E. 1954 Vordere und mittlere Schädelgrube bei Laboratoriums– und Hausäugetieren. 1. Acta Anat., *22:* 97–127.

Stadtmüller, F. 1949 Über mikrocephalen-Schädd und an diesen festgestellte enantioplastioche Erscheinungen. Z. Morph. Anthrop., *41:* 209–257.

Starck, D. 1953 Morphologische Untersuchungen am Kopf der Säugetiere, besonders der Prosimier, ein Beitrag zum Problem des Formwandels des Säugerschadels. Z. Wiss. Zool., *157:* 169–219.

Taylor, W. O. G. 1939 Effect of enucleation of one eye in childhood upon the subsequent development of the face. Tr. Ophth. Soc. U. K., I, *59:* 361–371.

Thoma, R. 1911 Untersuchungen über 'das Schadelwachstum und seine Störungen. 1. Die Spannung der Schädelwand. Virchow's Arch., *206:* 201.

Toldt, C. 1914 Brauenwülste, Tori supraorbitalis, und Brauenbogen, Arcus superciliaris und ihre mechanische Bedeutung. Mett. Anthrop. Ges. wein., *44:* 234–315.

Washburn, S. L. 1947 The relation of the temporalis muscle to the form of the skull. Anat. Rec., *99:* 239–248.

Washburn. S. L., and S. R. Detwiler 1943 An experiment bearing on the problems of physical anthropology. Am. J. Phys. Anthrop. n.s., *1:* 171–190.

Weidenreich, F. 1941 The brain and its role in the phylogenetic transformation of the human skull. Trans. Am. Philos. Soc., n.s., *31:* 321–442.

Weinmann, J. P., and H. Sicher 1955 Bone and bones. In: Fundamentals of Bone Biology, C. V. Mosby, St. Louis.

Wessely, K. 1920 Über Korrelationen des Wachstums (nach Versuchen am Auge). Z. Augenheilkunde, *43:* 654–681.

Witzig, K. 1940 Beitrag zur Frage nach der funktionellen Struktur der Dura mater cerebri des Menschen. Viertel. Naturforsch. Ges., Zürich, *85:* 71–97.

Young, R. W. 1957 Postnatal growth of the frontal and parietal bones in white males. Am. J. Phys. Anthrop., *15:* 367–386.

——— 1958 Trends in the evolution of the human neural skull: implications of an experimental study. Abstract, Am. J. Phys. Anthrop. (in press)

——— 1959a Age changes in the thickness of the scalp in white males. Human Biol., *31:* 74–79.

——— 1959b The influence of cranial contents on postnatal growth of the skull in the rat. Am. J. Anat., *105:* 383–415.

The Number of Hand-Wrist Centers

STANLEY M. GARN AND CHRISTABEL G. ROHMANN
Fels Research Institute, Yellow Springs, Ohio

The numerous ossification centers of the hand and wrist that appear during postnatal life offer a potential opportunity for an objective, quantitative measure of developmental status (cf. Flecker, '42; MacKay, '52; Sutow, '53; Acheson, '54). A count of hand centers, expressed perhaps as a percentage of the maximum, affords the simplest measure of osseous development without need for pictorial reference standards.

But such an enumeration poses problems of its own, that can only be resolved by longitudinally-collected data. For one thing, variability at different ages must be taken into account: when variability is small it is diffiicult to establish gradations of osseous status. Moreover, intercorrelations between successive ages must be determined on an individual basis. If children differ widly in status at different ages, a simple enumeration of hand-wrist centers has obvious limitations.

Furthermore, the representativeness of the hand must be known. While the hand does contribute 28 centers, out of the total of 60 used for evaluation, it is not certain whether the hand is representative of the remainder of the appendicular skeleton. Authors favoring the hand have assumed its representativeness, while authors advocating a more extensive radiographic survey have assumed that the hand is not representative. In either case definitive data have been lacking.

The present study, therefore, is concerned with the number of hand-wrist ossification centers present at various ages during infancy and childhood, the extent to which hand-wrist status at one age relates to hand-wrist status at another age, and the degree to which the hand is in agreement with the remainder of the appendicular skeleton during infancy and childhood. Recognizing the technical simplicity of a postero-anterior hand film, and the saving in radiation it affords, the central problem is whether a simple enumeration of centers can serve as a continuing index of individual developmental progress.

METHODS AND MATERIALS

The present study is based upon serial longitudinal radiographs of 154 Ohio-born boys and girls, selected on the basis of the most complete hand-wrist radiographic series, and excluding like-sexed siblings from the tabulations (Garn and Rohmann, '59, '60).

The number of postnatal ossification centers of the hand was individually ascertained at one, three, 6, 9 and 12 months and at half-yearly intervals thereafter (Garn and Shamir, '58). Sex and age-specific cumulative frequency curves were compiled from the raw data, and the 5th, 50th and 95th percentiles obtained by interpolation.

In addition to hand-wrist ossification counts from 0.08 through 10.0 years, the number of bony nuclei of the foot was counted for all subjects at 4.0 years of age. Furthermore, the "total" number of appendicular ossification centers was also enumerated at full birthdays, 2.0 through 6.0 years. Body parts considered included the hand and wrist, elbow, shoulder, hip, knee, lower leg and foot, as pictured in Garn and Shamir ('58, fig. 4) and described by Pyle and Sontag ('43).

Prior to computing correlation coefficients, all raw scores were converted into sex-specific normalized T-scores. For the most part intercorrelations involving the number of centers present at various ages were expedited by the use of the N. C. R. Electronic Computer. However, 36 of the 556 intercorrelations were completed on a desk calculator, again using normalized sex-specific T-scores. Mean intercorrelations involving particular time intervals were obtained by summing the z-transforms of individual values of r as described in Garn and Rohmann ('59), and following the method used by Garn, Lewis and Polacheck ('60).

Spot checks showed that secular trends could be ignored in these ossification data. Moreover, all correlations involved intra-individual comparisons, in which such trends would not be a complicating factor. Nevertheless, in considering the normative aspects of the findings, attention should be directed to the national origins, economic position and nutritive status of the population sample used in this study. For populations differing considerably in the timing and sequence of ossification centers, different correlations could be expected.

FINDINGS

As shown in table 1, where the 5th, 50th, and 95 percentiles are tabulated, the number of postnatal ossification centers of the hand and wrist increases rather slowly up to the first birthday. Thereafter, and until the fourth year, there is a rapid rise in the number of centers, followed by a period of slow increase until the full complement of 28 centers is attained. Throughout the age span considered, the girls are ahead of the boys, both with respect to number of centers and the age at completion. In fact, at 1.0, 1.5, and 2.0 years the median number of centers for the girls approximates twice that for the boys.

Variability in number of centers present, moreover, tends to be limited both during infancy and in the school years, as shown in figure 1. Below the first year in males and after the 6th year in females absolute variability in number of centers is too small to afford effective discrimination. Thus, the period of rapid increase in the number of hand-wrist centers proves to be the period in which a simple enumeration is potentially most useful in hand-wrist comparisons.

Since variability in hand-wrist centers is small during the first year, except for girls at 9 months of age, it is not surprising that the number of centers present at one, three, 6 and 9 months are poorly intercorrelated, as shown in table 2. Being advanced or retarded in hand-wrist ossification at one age, is barely predictive of ossification status as little as three or 6 months later. With marked irregularities in the

TABLE 1

Number of hand-wrist ossification centers from one month through 10.0 years

Age	Percentiles					
	Boys			Girls		
	5	50	95	5	50	95
years						
0.08	—	—	2.0	—	0.5	2.7
0.25	—	0.8	2.7	—	1.8	3.0
0.50	—	1.8	2.9	0.9	2.3	6.0
0.75	0.2	2.1	3.9	0.8	3.4	11.3
1.00	1.2	2.8	7.5	1.6	6.8	16.4
1.50	2.0	6.2	16.0	7.0	16.6	22.2
2.00	5.4	11.4	20.4	12.4	21.2	24.4
2.50	8.1	16.8	23.0	18.0	23.1	26.2
3.00	11.8	19.7	24.2	19.0	23.8	26.8
3.50	15.6	22.2	24.8	21.7	24.3	27.7
4.00	18.0	23.1	25.7	22.7	25.4	27.5
4.50	20.4	23.5	26.5	23.0	26.5	28.0
5.00	21.4	24.2	27.1	23.0	27.0	—
5.50	22.3	24.8	27.6	24.5	27.4	—
6.00	22.4	25.9	28.0	26.1	27.8	—
6.50	22.8	26.5	—	26.3	27.9	—
7.00	23.8	27.2	—	26.3	27.9	—
7.50	24.0	27.5	—	27.0	27.9	—
8.00	25.4	27.8	—	27.1	27.9	—
8.50	26.1	27.9	—	28.0	28.0	—
9.00	26.7	27.9	—	28.0	—	—
9.50	27.1	28.0	—	28.0	—	—
10.00	28.0	—	—	28.0	—	—

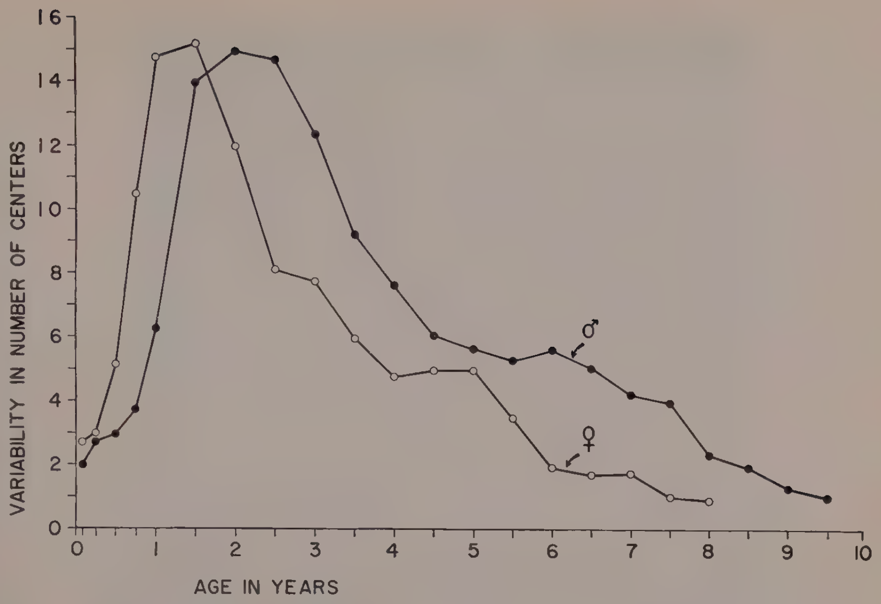


Fig. 1 Variability in the number of hand-wrist centers from 0.08 through 9.5 years. As shown, the difference between the 95th and 5th percentiles is large during the period of rapid increase in the number of centers.

TABLE 2

Correlations involving the number of hand-wrist centers during the first two years of life

Age	Intercorrelations—Boys[1]						
	0.08	0.25	0.50	0.75	1.00	1.50	2.00
years							
0.08	—	0.58[1]	0.34	0.26	0.30	0.16	0.01
0.25	*0.51*	—	0.27	0.28	0.31	0.22	0.07
0.50	*0.39*	*0.48*	—	0.58	0.22	0.20	0.22
0.75	*0.12*	*0.17*	*0.61*	—	0.47	0.28	0.24
1.00	*0.23*	*0.10*	*0.45*	*0.77*	—	0.70	0.52
1.50	*0.11*	*0.20*	*0.33*	*0.58*	*0.77*	—	0.77
2.00	*0.04*	*0.19*	*0.40*	*0.49*	*0.67*	*0.78*	—
	Intercorrelations—Girls[1]						

[1] From sex-specific normalized T-scores.

ppearance and sequence of centers, there s little tendency to “hold” percentile posiion during the first few years of life (cf. ig. 2).

The extent to which the number of ceners present at one age is related to the umber of centers present at another age vas further explored through the use of a 3 × 22 correlation matrix, involving 253 eparate correlations for each sex. Since he major question was constancy of relaive (or percentile) position over varying eriods of time, the individual correlations vere pooled in terms of advancing elapsed time. As shown in table 3, such mean intercorrelations varied in magnitude from 0.8, over a 6-month period, downward to 0.13, over an 8-year interval. Over an average of 4 years time, the mean intercorrelation approximated 0.4, too low for individual prediction though useful on a group basis and at the extremes of the distribution.

In considering the “representativeness” of the hand and wrist, as a measure of ossification status, the number of hand-wrist centers at 2.0, 3.0, 4.0, 5.0 and 6.0 years was individually compared to the total

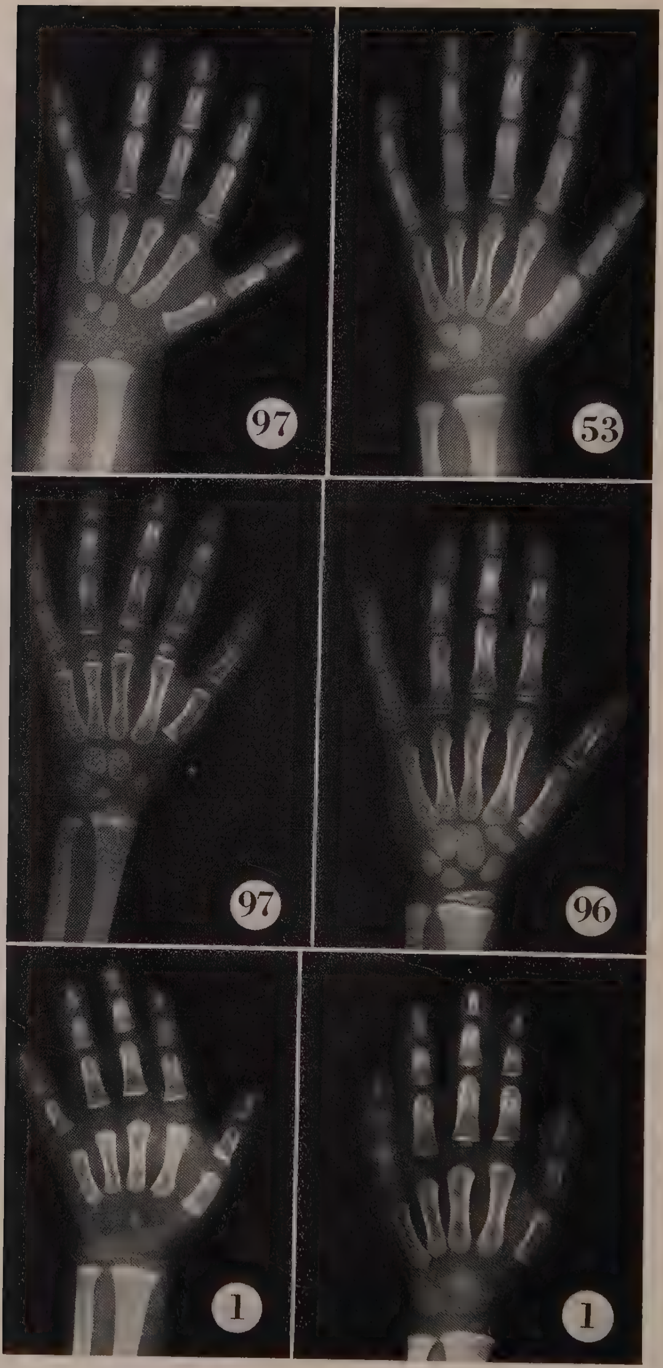


Fig. 2 Constancy and variability in hand-wrist ossification during the first three years of life. Above, Fels child 271 (female) dropping from the 97th percentile at 1.5 years to the 53rd percentile at 3.0 years. Middle, Fels case 140 (female) advanced at 1.5 years (97th percentile) and comparably advanced at 3.0 years (96th percentile). Below, Fels child no. 156 (male) remaining in the 1st percentile from 1.5 through 3.0 years.

TABLE 3

Mean intercorrelations for number of hand-wrist centers arranged according to elapsed time

Elapsed time	Number of correlations	Mean r[1]
years		
0.5	16	0.77
1.0	15	0.64
1.5	14	0.55
2.0	13	0.48
2.5	12	0.45
3.0	11	0.42
3.5	10	0.39
4.0	9	0.37[2]
4.5	8	0.37
5.0	7	0.36
5.5	6	0.35
6.0	5	0.28
6.5	4	0.27
7.0	3	0.21
7.5	2	0.20
8.0	1	0.13

[1] Mean combined-sex correlation coefficient, computed from sex-specific z-transforms of r.

[2] Median r over a 4-year period for 272 individual sex-specific correlation coefficients.

number of centers in the appendicular skeleton at the same ages, again using sex-specific normalized T-scores. The raw correlations, hand-wrist vs. "total" averaged 0.6 to 0.8, as shown in table 4. However, these correlations were artificially inflated by the fact that the hand and wrist contributed up to 28 (47%) of the total number of 60 centers. When the hand-wrist count was compared to the balance of the appendicular skeleton, involving 32 independent nuclei, the correlations dropped markedly by approximately 0.4, and to values as low as 0.16 (table 4). Thus the hand, though significantly related to osseous status in general, did not prove to be highly representative of the body as a whole.

In a further effort to make the number of hand-wrist centers useful on an individual basis, the combination of hand and foot was explored at 4.0 years of age. Such a combination involved up to 48 of the total of 60 nuclei, and it was reasonable to expect that the addition of 20 tarsal, metatarsal and phalangeal centers would markedly improve predictability. However, as shown in table 5, where sex-specific correlations are tabulated, there was no useful

TABLE 4

Correlations between hand-wrist and body centers

Correlation	Age	Boys		Girls	
		N	r[1]	N	r[1]
Hand-wrist vs. total[2]	2.0	69	0.81	71	0.84
Hand-wrist vs. balance[3]	2.0	69	0.53	71	0.47
Hand-wrist vs. total[2]	3.0	73	0.89	63	0.78
Hand-wrist vs. balance[3]	3.0	73	0.41	63	0.49
Hand-wrist vs. total	4.0	70	0.84	71	0.81
Hand-wrist vs. balance	4.0	70	0.52	71	0.45
Hand-wrist vs. total	5.0	46	0.78	28	0.88
Hand-wrist vs. balance	5.0	46	0.49	28	0.26
Hand-wrist vs. total	6.0	35	0.86	21	0.63
Hand-wrist vs. balance	6.0	35	0.37	21	0.16

[1] From normalized T-scores.

[2] Total number of centers as in Pyle and Sontag ('43).

[3] Total number of centers excluding those of the hand and wrist.

TABLE 5

Correlations between hand centers, foot centers and the "total" number of centers at 4.0 years

Correlation	Age	Boys		Girls	
		N	r	N	r
Hand-wrist vs. "total"[1]	4.0	67	0.85	69	0.78
Foot vs. "total"[1]	4.0	67	0.86	69	0.55
Hand and foot vs. "total"[1]	4.0	67	0.94	69	0.81

[1] Total number of centers as in Pyle and Sontag ('43).

increase in predictive efficiency. The hand and foot together (which are highly correlated) did not remedy the limitations of the hand alone.

It was evident that the number of hand-wrist centers, though valuable in group comparisons and in clinical studies, does not serve as a precise investigative tool for use in the growth appraisal of healthy children.

DISCUSSION

From these longitudinal analyses of longitudinal data it is clear that the number of hand-wrist ossification centers present at one age is not a generally useful measure of developmental status for individual normal children. Though distinctly applicable on a group basis (cf. Garn, Clark, Landkof and Newell, '60; Maranjian, '60) and for children beyond the 5th and 95th percentile limits, predictability from one age level to another is insufficiently high to commend a simple "carpal count" as a precise tool for serial growth evaluation.

During the first year of life, variability in the number of hand-wrist centers is small, precluding any successful division into advanced, moderate and retarded categories. Moreover, the nuclei that may be present (capitate, hamate and triquetral) have little communality with the later-appearing round bones and epiphyses as we have previously shown (Garn and Rohmann, '59). After the third or 4th year variability in the number of centers again becomes restricted, so that a simple enumeration is of value only for a limited time during infancy, except, of course, in endocrinopathies, infantile malnutrition, and growth failures.

Over a time lapse of no more than a year, intercorrelations involving the number of hand-wrist centers average approximately 0.6, useful on a group basis, and to a limited extent in assaying individual growth. Over a 4 year period the mean intercorrelation approximates 0.4, attesting to some consistency of developmental progress but not a useful one in individual analyses. Such low intercorrelations are explained by the autonomies exhibited by individual centers of ossification with respect to time of appearance (Garn and Rohmann, '59), to sequence of appearance (Garn, Rohmann and Robinow, '61), and to familial atypical patterns (Garn and Rohmann, '60). Obviously, predictability of hand-wrist counts could be improved by ignoring the carpal centers with their notably low communalities, and we are currently exploring such a corrected system.

Although the hand has been considered as representative of the body, the present data do not support this contention. Correlations of 0.7 to 0.8 between the number of hand-wrist centers and the total number of body centers are due largely to the large proportion of hand-wrist centers included in the total. Correlating the hand with the foot-knee-hip-shoulder-elbow summation, the values of r drop to 0.3–0.4 and below. This does not invalidate the use of the postero-anterior hand plate for objective assessments, particularly in growth abnormalities or endocrinopathies, but it does indicate that the hand alone is inadequate if the technique is simple enumeration, and applied to the appraisal of normal individual growth.

Assuming that the totality of appendicular centers suggested by Pyle and Sontag ('43), and used by Wilkins ('60) and others, does represent the optimum measure of developmental status, it might be thought that the hand and foot together, with a potential of 48 centers, would yield maximum information consistent with minimal radiation exposure. But including a total of 48 centers instead of only 28 barely increases predictability. The hand plus some area closer to the axial skeleton might prove the optimum combination.

Clearly, hand-wrist ossification counts, however reliable and objective, fall short of useful as indicators of normal developmental progress. It is thus too early to canonize particular techniques of assessment, until we know more about interrelationships in ossification and bone growth.

Nevertheless, hand-wrist radiographs, particularly serial radiographs, have much to offer. There are obvious differences in timing, sequence of appearance, and patterning that have been but little explored. In family-line and twin studies we have much to learn about genic determinants. Studies on protein malnutrition and cortisone treatment, and investigations on various racial groups will contribute much to our continuing knowledge. Instead of viewing the ossification of the hand and wrist as a closed subject, an accepted clinical tool, it is clear that it is a subject for concerted investigation, where the determinants of timing and sequence remain to be discovered.

SUMMARY

1. The number of postnatal ossification centers of the hand and wrist was investigated in 154 Ohio-born white subjects at 23 successive age intervals from one month through 10 years.

2. The number of centers at a given age was at best moderately correlated with the number of centers present at another age, with an average r of 0.40 over a 4-year interval.

3. Hand-wrist ossification counts did not prove adequately representative of the remainder of the appendicular skeleton at ages 2.0 through 6.0.

4. The combination hand-plus-foot, though accounting for a maximum of 48 of the 60 postnatal ossification centers yielded no marked improvement in predictability at 4.0 years of age.

5. It was concluded that the hand-wrist ossification count, though obviously useful in growth abnormalities and on grouped data, is not a precise measure of developmental progress in normal individuals.

ACKNOWLEDGMENTS

We are indebted to Dr. Edmund Churchill for use of the N. C. R. Electronic Computer and to Dorothy Clarke for help in the manuscript preparation. Financial support, in part, from research grant A-3816 of the National Institutes of Health is herein acknowledged.

LITERATURE CITED

Acheson, R. M. 1954 A method of assessing skeletal maturity from radiographs. J. Anat., *88:* 498–508.

Flecker, H. 1942 Time of appearance and fusion of ossification centers as observed by roentgenographic methods. Am. J. Roentgenol. Rad. Therapy, *47:* 97–159.

Garn, S. M., and C. G. Rohmann 1959 Communalities of the ossification centers of the hand and wrist. Am. J. Phys. Anthrop., *17:* 319–323.

——— 1960 Variability in the order of ossification of bony centers of the hand and wrist. Ibid., *18:* 219–230.

Garn, S. M., C. G. Rohmann and M. Robinow 1961 Increments in hand-wrist ossification. Ibid., *19:* in press.

Garn, S. M., and Z. Shamir 1958 Methods for Research in Human Growth. C. C Thomas, Springfield, Ill.

Garn, S. M., A. B. Lewis and D. L. Polacheck 1960 Interrelations in dental development. J. Dent. Res., in press.

Garn, S. M., A. K. Clark, L. Landkof and L. Newell 1960 Parental body build and developmental progress of the offspring. Science, *132:* 1555–1556.

MacKay, D. H. 1952 Skeletal maturation in the hand: a study of development in East African children. Trans. Roy. Soc. Trop. Med. Hygiene, *46:* 135–150.

Maranjian, G. 1960 Hand-wrist ossification in Saudi Arabian children. Paper presented at the International Congress of Ethnologists, Vienna, June, 1960.

Pyle, S. I., and L. W. Sontag 1943 Variability in onset of ossification in epiphyses and short bones of the extremities. Am. J. Roentgenol. Rad. Therapy, *49:* 795–798.

Sutow, W. W. 1953 Skeletal maturation in healthy Japanese children, 6 to 19 years of age. Comparison with skeletal maturation in American children. Hirs. J. Med. Sci., *2:* 181–191.

Wilkins, L. 1960 The Diagnosis and Treatment of Endocrine Disorders in Childhood and Adolescence. C. C Thomas, Springfield, Ill.

The Blood Groups of Chimpanzees

A-B-O GROUPS AND M-N TYPES

ALEXANDER S. WIENER AND EVE B. GORDON
From the Serological Laboratory of the Office of the Chief Medical Examiner of New York City, and the Division of Immunohematology of the Jewish Hospital of Brooklyn, N. Y.

Recently, Dr. Maitland Baldwin, Chief of the Surgical Neurology Branch of the National Institute of Neurological Diseases and Blindness, sent us blood samples from 14 chimpanzees who were being studied at that institute. This opportunity has been used to restudy the A-B-O groups and M-N factors of chimpanzees, and also to test their blood for the Rh-Hr factors, as well as a number of the more recently discovered human blood factors. In this paper it is proposed to present the results of the A-B-O and M-N tests, and in subsequent papers will be presented the results of the tests for the Rh-Hr and other blood factors.

The first study of the A-B-O blood groups of primates was carried out by Landsteiner and Miller in 1925. Among 15 chimpanzees tested, they found three with blood giving the reactions of the human blood group O and 11 giving reactions corresponding to the blood group A. When the blood of humans and chimpanzees was compared by direct cross-matching tests, Landsteiner and Miller found that in addition to the isoagglutinins anti-A and anti-B chimpanzee sera contained weak heteroagglutinins, so that chimpanzee sera not infrequently weakly clumped human group O cells, while human sera often clumped chimpanzee cells of group O. The reactions of such heteroagglutinins must be taken into account when anti-A and anti-B human sera are used for testing blood of lower primates[1]. Landsteiner and Miller pointed out that this difficulty could be avoided by using anti-A and anti-B reagents prepared by immunizing rabbits with human cells of group A and group B, respectively, and then absorbing with group O human cells to remove the species-specific agglutinins. (Failure to take heteroagglutinins into account caused errors in some of the early investigations by other workers.) The observations by Landsteiner and Miller have been confirmed and, by 1938, 92 chimpanzees had been tested (Wiener, '43) of whom 81 proved to be group A and 11 group O.

In their original study, Landsteiner and Miller also tested blood of other anthropoid apes. They reported that among 6 orangutans, two were group A, three were group B and one was group AB. Only one gibbon was tested who proved to be group A, while the blood of a gorilla which they tested could not be classified into any of the 4 A-B-O blood groups. Subsequently, Candela, Wiener and Goss ('40) were able to study blood and organs from a dead gorilla. They showed that while the gorilla's red blood cells were not clumped by either anti-A or anti-B sera, the serum contained anti-A but not anti-B agglutinins. Extracts of the salivary glands of this gorilla showed the presence of blood group substance B in high concentration. Thus, this gorilla belonged to group B, and while the B antigen was not demonstrable on the blood cells, it was present in the salivary glands and secretions. The same investigators then determined the blood groups of additional gorillas by testing their urines by the inhibition technic and found that of the 13 lowland gorillas (*G. gorilla*) all belonged to group B, while two mountain gorillas (*G. berengei*) both belonged to group A.

---

[1] In this paper, in conformity with the recommendation of the Committee on Medico-legal Problems of the American Medical Association (Wiener, Owen, Stormont and Wexler, '57), symbols for agglutinogens, phenotypes, and blood group systems are printed in regular type, symbols for blood factors and their corresponding antibodies in **boldface** type, and symbols for genes and genotypes in *italics*.

In tests on monkeys, it had previously been found that rhesus monkeys (*M. mulatta*) regularly had anti-**A** but not anti-**B** in their sera, but their red cells were not clumped by either anti-**A** or anti-**B** serum. Wiener, Candela and Goss ('42) then tested saliva and salivary glands from such monkeys and found them to contain high concentrations of group B substance. By carrying out similar tests on other species of monkeys, these investigators were able to show that Landsteiner's rule for the A-B-O blood groups holds in monkeys and gorillas as well as in chimpanzees and human beings, except that in the former species the reciprocal relationship between antigens and isoantibodies exists only between glands (or secretions) and serum, rather than between red blood cells and serum.

Wiener ('38) examined the blood cells of chimpanzees for their content of M and N agglutinogens. He found that some anti-**M** and anti-**N** reagents reacted with chimpanzee cells as well as with human red blood cells, while other similar reagents reacted exclusively with human red cells. Thus, he was able to demonstrate the existence of at least two different kinds of M factors, namely, factor $\mathbf{M_I}$ present in human M agglutinogen but absent from chimpanzee blood and factor $\mathbf{M_{II}}$ present in chimpanzee blood as well as human M blood. Some rabbit immune anti-**M** sera proved to be of specificity anti-$\mathbf{M_I}$, others of specificity anti-$\mathbf{M_{II}}$, while still others contained a mixture of anti-$\mathbf{M_I}$ and anti-$\mathbf{M_{II}}$, as proved by absorption experiments. A parallel situation was found to hold for the **N** factors. In fact, the blood of all the chimpanzees tested by Wiener proved to have both the factors $\mathbf{M_{II}}$ and $\mathbf{N_{II}}$. When these investigations were extended to other primates (Landsteiner and Wiener, '37), it was possible to demonstrate the existence of at least 5 different **M** factors in the human agglutinogen M, and a step-like evolution of the M agglutinogen from lower monkeys to man could be shown (Wiener, '43). In fact, an anti-**M** reagent suitable for typing human red blood cells was prepared by immunizing rabbits with cells of rhesus monkeys, and it was these experiments which led to the discovery of the Rh facto (Landsteiner and Wiener, '40).

From this review, it is clear that the re blood cells of chimpanzees contain an agglutinogen or agglutinogens similar to bu not identical with the human agglutinogens M and N. In the present paper, w propose to present further observations o the M-N factors of chimpanzee red bloo cells, with special reference to the use o seed agglutinins for such studies. In addition, further observations on the A-B- groups will be presented with special reference to the subgroups of A, and the secretor types.

MATERIALS AND METHODS

The blood of each of the 14 chimpanzee was identified by a distinctive name as wel as a number. The serum was separate from each blood sample by centrifugation and saline suspensions of the red bloo cells were prepared. Each cell suspensio was centrifuged, the supernatant fluid discarded, and the sedimented cells were resuspended in enough normal saline solution to make a 2% suspension. Simila once washed saline suspensions of standard cells were prepared from fresh bloo of human individuals of known groups O A_1, A_2, and B, as well as of types M, N an MN.

For determining the A-B-O groups, poten anti-**A** and anti-**B** sera of human origi were used, which had been prepared fro sera of volunteers who had been immunized by intra-muscular injections of commercial A and B blood group substance Because of their high titers, these ser could be used in dilutions at which th heteroagglutinins for chimpanzee red cell were not active. This obviated the us of anti-**A** and anti-**B** reagents prepared b immunizing rabbits, such as were recommended by Landsteiner, and had also bee used by the present authors in previou investigations. For subgrouping group blood, an anti-$\mathbf{A_1}$ reagent was used whic had been prepared by absorbing the seru of a selected group B donor with A_2 cells In addition, an extract of *Dolichos biflor* seeds was used (Krüpe, '56), which ha kindly been provided to us by Dr. Roy Fiske. A number of anti-**M** (lot numbe M43 and M4) and anti-**N** (lot numbe

N50, N10 and N105) reagents were available, which had been prepared by immunizing rabbits with human type M and type N blood, respectively, and suitably absorbed to remove the species specific agglutinins (Wiener, '43). A human anti-M serum was also used which had been obtained from a type N patient who had become sensitized by blood transfusions. Extracts of *Vicia graminae* seeds, kindly provided by Dr. Franz Ottensooser, which gave potent and specific reactions with human red cells having agglutinogen N (Ottensooser, '53) were also used in the present investigation. Moreover, the original anti-U serum was still available (Wiener, Unger and Gordon, '53) and was used in the present study at a dilution giving strong clumping of human cells.

The chimpanzee red cells were tested for their agglutinogen content by mixing a drop of red cell suspension with a drop of the appropriate antiserum on a Boerner well slide. The mixtures were rotated on a shaking machine for 10 minutes, and the reactions then recorded. In other experiments, a series of doubling dilutions of the antiserum was prepared, and a drop of each dilution placed in the corresponding tube of a series, and to each tube was added a drop of the cell suspension of the chimpanzee blood being examined. The reciprocal of the highest dilution of antiserum giving a one plus reaction was recorded as the titer of the serum for the cells, and where no tube showed a one plus reaction the titer was estimated by interpolation. Similar titrations were carried out with the serum of each chimpanzee against human red cells of groups O, A_1, A_2, and B, in order to determine the titer of the isoagglutinins in the chimpanzee sera. These titrations were set up in duplicate, and to the tubes of one set were added a drop of a 10% buffered saline solution of gum acacia (Wiener, Wexler and Hurst, '49). In this way two titers were obtained, one in saline solution and the other in acacia.

The saliva specimens were collected from the chimpanzees while they were under ether anesthesia. (One of the chimpanzees, Queenie, was dead at the time that the saliva specimens were collected, but specimens were obtained from all of the remaining 13 chimpanzees.) In cases where the flow of saliva was inadequate, injections of small amounts of physostigmine were given. The tubes containing the saliva were placed in boiling water for 10 minutes in order to inactivate the enzymes. After this had been done by Dr. Maitland Baldwin of the Branch of Neurosurgery of the National Institute of Neurological Diseases and Blindness in Bethesda, Maryland, the specimens were forwarded to the authors in New York City by special delivery mail. Most of the specimens arrived in good condition; there were a few in tubes in which the saliva had apparently dried, and to each of these 5 drops of saline were added in order to reconstitute the saliva. The salivas were then tested for their group substances by the quantitative inhibition technique as described by Wiener ('43) and by Wiener, Gordon and Evans ('58).

To insure complete objectivity of all findings, the tests were set up by one of us (E.B.G.) while the other (A.S.W.) read the reactions blind. In this connection, we wish to acknowledge the assistance of Mrs. D. McSee, Miss L. Hinds and Miss P. Ryan, who also helped in setting up the various tests.

RESULTS

A-B-O groups. The results of the tests on the chimpanzee blood for the A-B-O groups are shown in table 1. None of the blood suspensions of the 14 chimpanzees reacted with the anti-B serum, while 12 of the 14 bloods were agglutinated by the anti-A serum. Accordingly, 12 of 14 chimpanzees appear to belong to group A while two are group O. This corresponds well with Landsteiner and Miller's original results, since they found 11 group A and three group O among 14 chimpanzees tested. In previous studies by Wiener and Wade ('45) on 10 chimpanzees, 9 proved to be group A and one group O, while in a study by Wiener, Gavan and Gordon ('53) 7 chimpanzees proved to be group A and one group O. Thus, the present authors have tested a total of at least 32 chimpanzees, of whom 28 were group A and 4 were group O. To date, no chimpanzee of group B or group AB has been found.

When our results are combined with those in the literature, among a total of

TABLE 1

A-B-O groups of 14 chimpanzees

Blood of	Reactions[1] of cells with		Titers[1] of chimpanzee sera with human cells in								A-B-O groups of chimpanzees
			Saline				Acacia				
	Anti-A	Anti-B	0	A_1	A_2	B	0	A_1	A_2	B	
Chimpanzees											
1. Iris	–	–	0	12	2	56	0	180	180	500	O
2. Evelyn	++	–	0	0	0	4	0	0	0	32	A
3. Sampson	++	–	0	0	0	5	0	0	0	80	A
4. Jerry	++	–	0	0	0	0	0	0	0	3	A
5. Cindy	++	–	0	0	0	11	0	0	0	44	A
6. Queenie	++	–	0	0	0	4	0	0	0	80	A
7. Bike	++	–	0	0	0	14	0	0	0	160	A
8. Patch	++	–	0	0	0	14	0	0	0	180	A
9. Tiny	++	–	0	0	0	6	0	0	0	60	A
10. Lady	++	–	0	0	0	14	0	0	0	180	A
11. Georgie	++	–	0	0	0	6	0	0	0	160	A
12. Baldy	++	–	0	0	0	12	0	0	0	180	A
13. Dotty	++	–	0	0	0	5	0	0	0	120	A
14. J. B.	–	–	0	12	1	16	0	80	2	500	O
Controls:											
human cells											
O	–	–									
A_1	++	–									
A_2	++	–									
B	–	++									

[1] The strength of the reactions is indicated by the number of pluses, three plus (+++) represen ing the strongest reaction possible (one large clump). The titer in units is the reciprocal of the highe dilution of the serum giving a one plus (+) reaction with the test cells.

124 chimpanzees, there were 109 (or 87.9%) group A and 15 (or 12.1%) group O. Therefore, if p and r represent the frequencies of genes I^A and I^O, respectively, $p = 65.2\%$ and $r = 34.8\%$, in these 124 chimpanzees (Wiener and Wexler, '58).

The grouping reactions on the chimpanzee red cells were confirmed by testing the chimpanzee sera for their isoagglutinin content. None of the chimpanzee sera clumped human group O cells, indicating that any heteroagglutinins which might have been present in the sera were not active under the conditions of the test. As expected, the sera of all 12 group A chimpanzees clumped human group B cells but not human group A cells. However, there was considerable variation in the titers of isoagglutinins, ranging from no reaction in saline medium to a titer of 14 units. In acacia, the titers were consistently higher, the lowest titer being only three units and the highest 180 units. The sera from the two group O chimpanzees reacted with human group A as well as group B cells, and in both chimpanzees the anti-B titers were higher than the anti-A titers. Moreover, as has been found in human being (Wiener and Unger, '55) the isoantibod titers of the sera from the group O chimpanzees are significantly higher than thos of the group A chimpanzees. Althoug further tests were not done, it seems like that the serum of Iris (Chimpanzee no. in table 1) contains anti-C as well as ant A and anti-B (Wiener, '53).

Subgroups of A. In our previous studi on the subgroups of A of chimpanzee only anti-A_1 reagents of human origin ha been used. The weak reactions obtaine were difficult to interpret because of th possibility that such antisera might al contain weak heteroagglutinins for chimpanzee red blood cells. The fact that th present series of chimpanzees included tw of group O made possible a controlle study of the subgroup reactions. In add tion to human antisera, extracts of seed of *Dolichos biflorus* were available whic give strong reactions with human su group A_1 cells. To reduce the chance error the tests for the subgroups of A we carried out by the titration method, because titration tests give more reliable r

TABLE 2

Results of subgroup tests on chimpanzee red blood cells

Blood of	Blood group	Titers of human anti-A_1 (absorbed group B serum) for cells	Titers of extract of seeds of *Dolichos biflorus* for cells
Chimpanzees			
1. Iris	O	0	0
2. Evelyn	A	2	0
3. Sampson	A	6	0
4. Jerry	A	2	0
5. Cindy	A	4	0
6. Queenie	A	5	0
7. Bike	A	4	0
8. Patch	A	3	0
9. Tiny	A	5	0
10. Lady	A	4	0
11. Georgie	A	3	0
12. Baldy	A	4	0
13. Dotty	A	5	0
14. J. B.	O	0	0
Controls (Human cells)	O	0	0
	A_1	20	10
	A_2	0	0

ults than one tube agglutination tests. The results obtained are shown in table 2.

The human anti-A_1 serum had a titer of 20 units for human subgroup A_1 cells. This antiserum failed to agglutinate the chimpanzee group O cells, showing that it contained at most only negligible amounts of heteroagglutinins. The serum, however, clumped the cells of all the group A chimpanzees, but the titers for these cells were significantly lower than for human subgroup A_1 cells. These titers averaged about 4 units or about one-fifth the titer for human A_1 cells. (The titers for cells from individual chimpanzees ranged from 2 to 6 units, but such variations are within the limits of error of the titration method.) The extract of *Dolichos biflorus* seeds had a titer of 10 units for human subgroup A_1 cells, but failed to agglutinate any of the group A chimpanzee bloods under the conditions of the tests.

One may conclude from these observations that group A chimpanzees belong to a subgroup intermediate between the human subgroups A_1 and A_2, corresponding to the so-called subgroup $A_{1,2}$ in man. Subgroup $A_{1,2}$ occurs most frequently among Negroes, and is much less common among Caucasians, and has not been found in Mongolians (Wiener, '53).

Secretor types. The results of the quantitative inhibition tests on the saliva of the chimpanzees is shown in table 3. At the time that these specimens were collected, one of the chimpanzees, Queenie, was dead, but all the remaining 13 chimpanzees were tested. As can be seen from the table, the saliva from all the group A chimpanzees strongly inhibited the anti-A and anti-**H** reagents, but not the anti-**B** reagent. The saliva from the two group O chimpanzees inhibited the anti-**H**, but not the anti-A or anti-**B** reagents. Thus, all 13 chimpanzees tested are secretors. It is of interest to note that the inhibition titers of chimpanzee saliva are about the same as those of human secretor salivas. Also, as in the case of human saliva, group O saliva inhibits anti-**H** to a higher dilution than group A saliva.

M-N types. For the direct agglutination tests for factors M and N we fortunately had available exceptionally potent anti-**M** and anti-N reagents prepared from immune rabbit sera. As shown in table 4, the blood cells from all 14 chimpanzees were strongly clumped by both these reagents. As it has been pointed out in previous papers (Wiener, '43) this does not prove that all chimpanzees belong to a type MN identical with the human type MN. If, in chimpanzees, the M-N types were inherited as in man, the frequency of type MN (blood with both factors **M** and N) could not exceed 50 per cent. Obviously, a population could not remain 100 per cent type MN, because when two type MN individuals mate, they produce 25 per cent type M, 25 per cent type N and 50 per cent type MN offspring. These results therefore mean that the blood cells of chimpanzees have an agglutinogen or agglutinogens different from the human agglutinogens M and N, though having blood factors in common with both the human agglutinogens M and N. As Wiener has pointed out, the number of blood factors characterizing each agglutinogen is unlimited theoretically, and the number actually found depends largely on one's enterprise and ingenuity in searching for and finding antisera of new specificities (Wiener and Wexler, '52). Thus, as Wiener and Landsteiner have demonstrated, and as will be seen also from the

TABLE 3

Tests on saliva of 13 chimpanzees for A-B-O blood group substances

Saliva of	Reactions with A_2 cells of anti-A reagent treated with saliva dilutions						Reactions with B cells of anti-B reagent treated with saliva dilutions					Reactions with O cells of anti-H reagent treated with saliva dilutions				
	Undil.	1:4	1:16	1:64	1:256	1:1024	Undil.	1:4	1:16	1:64	1:256	Undil.	1:4	1:16	1:64	1:256
Chimpanzees																
1. Iris	+±	++	++	++	++	++	++	++	++	++	++	—	—	—	—	tr.
2. Evelyn	—	—	—	—	—	+	++	++	++	++	++	—	—	tr.	+±	++
3. Sampson[1]	—	—	—	—	—	±	++	++	++	++	++	—	—	tr.	++	++
4. Jerry	—	—	—	—	tr.	+±	++	++	++	++	++	—	—	—	tr.	++
5. Cindy	—	—	—	—	+	++	++	++	++	++	++	—	—	—	tr.	++
6. Queenie[2]																
7. Bike	—	—	—	—	tr.	+	++	++	++	++	++	—	—	—	tr.	++
8. Patch	—	—	—	—	—	±	++	++	++	++	++	—	—	—	—	tr.
9. Tiny	—	—	—	—	tr.	+±	++	++	++	++	++	—	—	—	tr.	+±
10. Lady	—	—	—	—	—	±	++	++	++	++	++	—	—	—	tr.	++
11. Georgie[1]	—	—	—	—	tr.	+	++	++	++	++	++	—	—	—	+	++
12. Baldy	—	—	—	—	tr.	++	++	++	++	++	++	—	—	—	+	++
13. Dotty	—	—	—	—	±	+±	++	++	++	++	++	—	—	—	—	+±
14. J. B.	++	++	++	++	++	++	++	++	++	++	++	—	—	—	—	—
Controls:																
Human saliva																
O Se	++	++	++	++	++	++	++	++	++	++	++	—	—	—	tr.	++
A se	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++	++
Commercial group substance	—	—	—	—	—	tr.	—	—	—	tr.	++	—	—	—	tr.	++

[1] These specimens were dried out when received, and were reconstructed by adding 5 drops of saline solution to the tube in which the saliva had been placed.

[2] Deceased when these tests were carried out.

TABLE 4

Results of tests for blood factors **M** *and* **N** *on blood cells of 14 chimpanzees*

Blood of	Results of tests for M factors			Results of tests for N factors						Anti-U (Direct reactions)	M-N types of Chim-panzees
	Rabbit anti-M43 (Direct reactions)	Rabbit anti-M4 (Titers)	Human anti-M (Titers)	Rabbit anti-N50 (Direct reactions)	Rabbit anti-N50 (Titers)	Rabbit anti-N10 (Titers)	Rabbit anti-N105 (Titers)	Seed extracts Vicia graminae			
								a (Titers)	b (Titers)		
Chimpanzees											
1. Iris	++±	6	220	++±	8	0	2	4	24	—	$(MN_1)^{Ch}$
2. Evelyn	++±	3	120	++±	7	0	3	0	0	—	$(MN_2)^{Ch}$
3. Sampson	++±	4	200	++±	6	0	3	3	12	—	$(MN_1)^{Ch}$
4. Jerry	++±	3	60	++±	7	0	3	5	16	—	$(MN_1)^{Ch}$
5. Cindy	++±	12	220	++±	6	0	4	0	0	—	$(MN_2)^{Ch}$
6. Queenie	++±	7	120	++±	8	0	4	12	24	—	$(MN_1)^{Ch}$
7. Bike	++±	12	110	++±	6	0	4	0	0	—	$(MN_2)^{Ch}$
8. Patch	++±	4	220	++±	6	0	3	0	0	—	$(MN_2)^{Ch}$
9. Tiny	++±	6	110	++±	6	0	4	0	0	—	$(MN_2)^{Ch}$
10. Lady	++±	14	200	++±	8	0	4	0	0	—	$(MN_2)^{Ch}$
11. Georgie	++±	6	120	++±	6	0	4	4	14	—	$(MN_1)^{Ch}$
12. Baldy	++±	7	140	++±	8	0	4	3	22	—	$(MN_1)^{Ch}$
13. Dotty	++±	11	200	++±	7	0	4	6	24	—	$(MN_1)^{Ch}$
14. J. B.	++±	4	140	++±	6	0	2	0	0	—	$(MN_2)^{Ch}$
Controls (*human cells*)											
Type M	++±	22	80	—	0	0	0	0	0	++±	
Type MN	++±	20	30	++±	8	5	3	2	14	++	
Type N	—	0	0	+++	16	7	8	6	16	++	

results of the present study, comparative tests with anti-**M** and anti-**N** on the bloods of lower primates prove that the human agglutinogens M and N are each characterized by a multiplicity of blood factors.

For example, as shown in table 4, the anti-**M** reagent of rabbit origin used has a significantly higher titer (about 20 units) for human type M and type MN blood than for chimpanzee blood (average titer only 7 units). In contrast, the anti-**M** reagent of human origin, which was used in our experiments, has a lower titer for human M blood than for chimpanzee blood. Obviously, therefore these two reagents must detect different blood factors of the human agglutinogen M. Moreover, in previous studies Wiener ('38) had shown that it is possible to prepare certain anti-**M** reagents which fail to clump chimpanzee blood cells at all. Similarly, as shown in table 3, certain anti-**N** reagents prepared from immune rabbit sera react with almost the same titer with chimpanzee blood as with human containing agglutinogen N, while other anti-**N** reagents fail to clump chimpanzee blood cells at all.

The results up to this point demonstrate that blood cells from *all* chimpanzees have blood factors in common with *both* human agglutinogens M and N. In chimpanzees, however, these blood factors could be serological attributes of a single agglutinogen rather than of two agglutinogens as in man. The chimpanzee M-N blood type may therefore be designated as $(MN)^{Ch}$, to indicate its similarity to human blood of type MN, and at the same time to emphasize the differences.

The most unexpected and interesting results were obtained in the tests carried out with reagents prepared from *Vicia graminae* seeds. For these tests, two extracts of different potencies were used, and, as table 3 shows, the two sets of readings gave parallel results. The blood cells of 7 of the 14 chimpanzees were strongly clumped by this reagent, while the other 7 blood samples failed to react. Obviously, therefore, the extract of *Vicia graminae* seeds detects a different kind of N factor from that detected by the anti-N immune rabbit sera. The results indicate that only about 50% of the chimpanzees tested share this factor with the human agglutinogen N. Such chimpanzees may assigned the symbol $(MN_1)^{Ch}$, while chin panzees lacking the *Vicia graminae* bloo factor **N** may be assigned the symb $(MN_2)^{Ch}$.

In an earlier study by Levine, Otte sooser, Celano and Pollitzer ('55), it w found that the blood of 4 of 13 chimpa zees gave reactions with extracts of *Vic graminae* seeds comparable to those human blood with agglutinogen N, whi 9 failed to react. Combining the two seri the total becomes 27 chimpanzees whom 11 are type $(MN_1)^{Ch}$ and 16 a type $(MN_2)^{Ch}$. Assuming that these tw types of blood are determined by corr sponding allelic genes, L^1 and L^2, then th frequency in this small series of 27 chim panzees of gene $L^2 = \sqrt{16/27} = \sqrt{0.59}$ $= 0.77$ or 77%, and the frequency of gen $L^1 = 0.23$ or 23%.

The blood cells of the 14 chimpanze were also tested with anti-U reagent pr pared from the serum of the original ca reported by Wiener et al. ('54). This re gent detects a blood factor **U** related to th M-N system. The factor has been foun in the blood of all Caucasians tested, b absent from 1.2% of Negroes tested New York City (Wiener, Unger and Cohe '54). Bloods lacking the factor have bee found to be most frequent in Africa, an as Greenwalt et al. ('54) have shown a bloods lacking the blood factor **U** also lac both the factors **S** and **s** of the M-N system. As shown in table 3, the bloo of all chimpanzees failed to react wit the anti-U serum and since they therefo lack factor U, they might perhaps be e pected also to lack factors S and s.

DISCUSSION

As has been pointed out, approximate 88 per cent of the chimpanzees tested b long to group A and 12 per cent to grou O. Moreover, tests on their saliva indica that all or almost all chimpanzees a secretors. The titration experiments c chimpanzee sera described in this pap indicate that in group O chimpanzees th isoagglutinin titers are higher than group A chimpanzees, just as in ma This suggests that when a group O fema and a group A male chimpanzee mat they might have offspring with A-Bmolytic disease. Indeed it is conceiv- le that occasional neonatal deaths or en stillbirths or miscarriages in chim- nzees could be traced to this mechasm, as in man (Wiener, Freda, Wexler d Brancato '60). This would imply a lective action against heterozygotes, ading to the loss of equal numbers of and I^O genes in each generation. Over period of thousands of generations, this ight be expected eventually to lead to e elimination of the less common gene f. Wiener, '42). This raises the question how the distribution $p = 65.2\%$ and $= 34.8\%$ was attained by the pres- t chimpanzee population. The explana- on appears to be that other factors af- cting gene frequencies have a more tent effect than this selective action ainst heterozygotes. For example, isola- n, inbreeding, migration, famine, acci- nts, and epidemics can bring about anges in gene frequencies in a single neration, which this weak selective ac- n against heterozygotes would require ousands of generations to achieve.

Unfortunately, few blood grouping tests ve been carried out on other anthropoid es. As already mentioned, Landsteiner d Miller tested a single gibbon and und him to belong to group A. The esent authors had an opportunity a few ars ago to test the blood of a gibbon d found him to belong to group B. The actions of this gibbon's blood was in ery way comparable with human blood group B. In addition, as already men- oned, Landsteiner and Miller found nong 6 orang-utans, two group A, three oup B and one group AB. The total umber of these apes tested to date is ill too small to permit any final conclu- ons as to the A-B-O distribution in gib- ons and orang-utans.

Judging from the results of the A-B-O sts, among the anthropoid apes, gorillas e the most remote from man. In gorillas, e A-B-O blood group cannot be deter- ined by testing the red blood cells, be- use as has been pointed out, the group ecific substances are lacking from the d blood cells and are present only in the gans and secretions. As shown by iener, Candela and Goss, a similar situa- on obtains in the lower monkeys, namely, monkey red blood cells fail to clump in anti-A and anti-B sera, but there is a reciprocal relationship between the isoagglutinins in serum and the blood group substances in the organs and secretions. One may infer from these results, in conformity with other evidence, that of the anthropoid apes gorillas are most closely related to the lower monkeys, while chimpanzees are most closely related to man.

As has been demonstrated, the blood cells of all group A chimpanzees gave reactions intermediate between those of human subgroups A_1 and A_2. Moreover, all chimpanzees appear to lack the blood factor U. Among humans, Africans have the highest incidence of blood with these characteristics. It is of interest to point out that, as will be shown in the second paper, the reactions of chimpanzee blood with Rh-Hr antisera more closely resemble those of blood from Negroes than those of Whites and Mongolians. In order to forestall any false implications from these findings, the present authors suggest the following interpretation. Since Negroes and chimpanzees are both geographically located in Africa, they have been subjected to the same environment, and this would tend to favor the survival of similar mutations. The occurrence of such parallel mutations does not imply, however, the existence of any closer zoological relationship than exists between albino rabbits and albino human beings.

The blood grouping reactions indicate that chimpanzee group O blood resembles human group O blood more closely than human group A blood resembles human group O blood, and, similarly, there is a closer resemblance between chimpanzee group A blood and human group A blood, than between human A and human O or B. Therefore, an initial transfusion of chimpanzee group O blood would probably be better tolerated by a group O human recipient than human group A blood. Such a transfusion of chimpanzee blood, however, would probably sensitize the human recipient against agglutinogens which all chimpanzee blood cells share and which are lacking from human blood cells. As a result, there would be an increase in the titer of the species heteroagglutinins for chimpanzee blood cells, so that a repeat transfusion of chimpanzee blood could give rise to a severe hemolytic reaction. While this experiment has never been carried out, Landsteiner and Levine ('32) have carried out reverse experiment, namely, they have transfused chimpanzees with human red blood cells. Three chimpanzees immunized in this way produced immune heteroagglutinins with titers for human cells of 1280, 640 and 320 units, respectively. When the sera of the immunized chimpanzees were matched against one another's red blood cells, clumping was observed in certain combinations, indicating the existence of individual differences among their red cells. Landsteiner and Levine remarked that with the use of these antisera, after absorption with human red cells to remove heteroagglutinins, comparable individual differences were observed by them in human red cells, independent of the A-B-O blood groups. These experiments were done in 1932, before the Rh factor was discovered, and it would be worthwhile to repeat them at the present time, because with the knowledge and techniques which have since been acquired such experiments might lead to the discovery of hitherto unknown blood factors in human blood.

The results of the M-N tests indicate that the blood of all chimpanzees contain M-like and N-like blood factors, confirming the previous reports Wiener ('43). Tests with seed extracts of *Vicia graminae* show that there are at least two kinds of agglutinogens in chimpanzees. Thus, this reagent, which in man shows no differences among blood samples having the **N** blood factor, in chimpanzees unexpectedly demonstrates the existence of individual blood differences. Recently, seeds have been found (Allen, '59), which have lectins apparently specific for human cells having agglutinogen M. It is planned to test chimpanzee blood with such lectins, and such studies may throw further light on the M-N types and the mechanism of their hereditary transmission in chimpanzees.

SUMMARY

1. Of 14 chimpanzee bloods tested, 12 proved to be group A and two group O. When these findings are combined with the results of previous studies by the pre ent authors and by others, there is a tot of at least 124 chimpanzees that hav been tested to date, of whom 109 we group A and 15 group O, giving the ge frequencies, $p = 65.2\%$ and $r = 34.8\%$ The blood cells of all the group A chim panzees gave reactions resembling thos of the human intermediate subgroup A_1

2. The isoagglutinin titers of the tw group O chimpanzees proved to be signi icantly higher than those of the 12 grou A chimpanzees. This suggests that ma ings between group O females and grou A male chimpanzees might give rise t A-B-O hemolytic disease, as in man.

3. Saliva from 13 of the 14 chimpanzee were tested for their content of blo group substances. All 13 chimpanze proved to be secretors.

4. All chimpanzees have both **M** and N like blood factors. However, in tests wit anti-N lectins, prepared from *Vicia gra inae* seeds, the blood cells of only 7 of th 14 chimpanzees were clumped while th blood cells of the other 7 chimpanzee failed to react. Thus, two sharply define M-N types can be distinguished amon these chimpanzees, to which the symbol $(MN_1)^{Ch}$ and $(MN_2)^{Ch}$ have been assigne None of the blood specimens from the 1 chimpanzees were agglutinated by anti- serum.

5. Judging from the results of the A-B- tests, of the anthropoid apes chimpanzee appear to be most closely related to ma while gorillas give reactions indicati that they are most distantly related to ma and most closely related to monkeys.

6. Immunization experiments with hu man red blood cells on chimpanzees migh lead to the discovery of new blood facto in human red cells.

ACKNOWLEDGMENT

These studies were carried out with th technical assistance of Mrs. Doris McSee Miss Louella Hinds and Miss Patrici Ryan. This investigation was made pos sible only through the kind collaboratio of Dr. Charles S. Bucknam and Dr. Mai land Baldwin of the Branch of Neurosur ery of the National Institute of Neurolo ical Diseases and Blindness in Bethesd Maryland, who provided the blood spec

ens from their colony of chimpanzees, hich were used in this study.

LITERATURE CITED

len, N. K. 1959 Lectins of anti-M and anti-N specificity. Meeting of the American Association of Blood Banks, Chicago, Ill.

ndela, P. B., A. S. Wiener and L. J. Goss 1940 New observations on the blood group factors in Simiidi and Cercopithecidae. Zoölogica, *25:* 513–521.

eenwalt, T. J., T. Sasaki, R. Sanger, J. Sneath and R. R. Race 1954 An allele of the S(s) blood group genes. Proc. Nat. Acad. Sci., *40:* 1126.

üpe, M. 1956 Blutgruppenspezifische Pfänzliche Eiweisskörper (Phytagglutinins). Ferdinand Enke, Stuttgart.

ndsteiner, K. 1928 Sur les propiétés sérologiques du sang des antropoïdes. Compt. Rend. Soc. Biol., *99:* 658–660.

ndsteiner, K., and P. Levine 1932 Immunization of chimpanzees with human blood. J. Immunol., *22:* 397–400.

ndsteiner, K., and C. P. Miller 1925 Serological studies on the blood groups of anthropoid apes. J. Exp. Med., *43:* 853–862.

ndsteiner, K., and A. S. Wiener 1937 On the presence of M agglutinogens in the blood of monkeys. J. Immunol., *33:* 19–25.

——— 1940 An agglutinable factor in human blood recognizable by immune sera for rhesus blood. Proc. Soc. Exp. Biol. and Med., *43:* 223–224.

vine, P., F. Ottensooser, M. J. Celano and W. Pollitzer 1955 On reactions of plant anti-N with red cells of chimpanzees and other animals. Amer. J. Phys. Anthrop., *13:* 29.

tensooser, F., and K. Silberschmidt 1953 Hemagglutinin anti-N in plant seeds. Nature, *172:* 914.

iener, A. S. 1938 The agglutinogens M and N in anthropoid apes. J. Immunol., *34:* 11–18.

——— 1942 Rh factor and racial origins. Science, *96:* 407–408.

——— 1943 Blood Groups and Transfusion, 3rd edition. C. C Thomas, Springfield Ill.

——— 1943 Evolution of the human blood group factors. Amer. Naturalist, *77:* 199–210.

——— 1953 The blood factor C of the A-B-O system, with special reference to the rare blood group C. Ann. Eugen., *18:* 1–8.

Wiener, A. S., P. B. Candela and L. J. Goss 1942 Blood group factors in the blood organs and secretions of primates. J. Immunol., *45:* 229–235.

Wiener, A. S., V. J. Freda, I. B. Wexler and G. J. Brancato 1960 Pathogenesis of A-B-O hemolytic disease. Amer. J. Obst. and Gynec., *79:* 567–592.

Wiener, A. S., J. A. Gavan and E. B. Gordon 1953 Blood group factors in anthropoid apes and monkeys. II. Further studies on the Rh-Hr factors. Amer. J. Phys. Anthrop., *11:* 39–45.

Wiener, A. S., E. B. Gordon and A. Evans 1958 The value of anti-H reagents (*Ulex europaeus*) for grouping dried blood stains. Amer. J. Forensic Sci., *3:* 493–502.

Wiener, A. S., R. D. Owen, C. Stormont and I. B. Wexler 1957 Medicolegal applications of blood grouping tests. A report of the Committee on Medicolegal Problems. J. Amer. Med. Assoc., *164:* 2036–2044.

Wiener, A. S. and L. J. Unger 1955 Excess of group O mothers in A-B-O hemolytic disease, with special reference to the role of the blood factor C. Exp. Med. and Surg., *13:* 204–224.

Wiener, A. S., L. J. Unger and L. Cohen 1954 Distribution and heredity of the blood factor U. Science, *119:* 734–735.

Wiener, A. S., L. J. Unger and E. B. Gordon 1953 Fatal hemolytic reaction caused by sensitization to a new factor U. J. Amer. Med. Assoc., *158:* 1444–1446.

Wiener, A. S. and M. Wade 1945 The Rh and Hr factors in chimpanzees. Science, *102:* 177.

Wiener, A. S. and L. B. Wexler 1952 The mosaic structure of red blood cell agglutinogens. Bacteriol. Rev., *16:* 69–87.

——— 1958 Heredity of the Blood Groups. Grune & Stratton, New York City.

Wiener, A. S., I. B. Wexler and J. H. Hurst 1949 The use of exchange transfusion for the treatment of severe erythroblastosis due to A-B sensitization with observations on the pathogenesis of the disease. Blood, *4:* 1014–1032.

Cranial Contours in the Australian Aboriginal

L. J. RAY
Department of Anatomy and Histology,
University of Melbourne, Victoria, Australia

The work of Benington ('11) and its ater amplification by Tildesley ('21) pro- ided a technique for the measurement of ranial contours. This technique was used y Wagner ('37) in his study of the Oce- nic Races and (with some modifications), y Wunderly ('43) in his study of the eilor Skull. The present work records measurements made on both male and emale aboriginal skulls collected from a elatively localized area in the south east f Australia.

Contour tracings, and the measure- ments which can be obtained from them, ermit not only an accurate portrayal of he size and shape of the skull in different lanes, but also an assessment of any symmetry which may be present.

MATERIAL AND METHODS

The material used was from the Murray lack Collection in the University of Mel- ourne (Sunderland and Ray, '59) and ontour tracings were made on 101 male nd 101 female skulls. The only selection f the material other than numerical was n the basis of the physical condition of he skull, those damaged or unduly deli- ate being rejected. Sex was determined y reference to the pelvis.

Tracings were made in three planes, ertical or transverse, horizontal and agittal, each mutually at right angles and ith the skull fixed in the Frankfurt plane. onsiderable care was necessary in fixing he skull in its position in the kubus and nce fixed it was not shifted until all the acings were completed.

In order to fix the skull in the Frankfurt ane, the three basic points of reference ere marked using the criteria advocated y Buxton and Morant ('33). The clamp as then attached to the occiput and with he kubus resting on a flat surface, the ull was adjusted until the two poria and the left orbitale were in the same horizontal plane. It was also necessary to ensure that the two poria were in the same coronal plane. The position of the skull having been fixed and checked the tracings were made by the aid of a scriber. On completion of the tracings the position of the skull was rechecked to ensure that no shift in position had occurred.

Vertical or transverse contour. With the face downwards, the point of the scriber was brought up to the left porion. The pencil was then allowed to touch the paper and make its tracing while the pointer was moved around the skull until it reached the right porion. In this way a tracing was obtained through the skull in the plane of the poria at right angles to the Frankfurt plane.

Horizontal contour. The kubus was placed on the tracing table with the base of the skull upwards and the horizontal contour taken through the glabella and parallel to the Frankfurt plane. As pointed out by Buxton and Morant ('33) the glabella is not a point capable of precise definition but is often an area. In order to reduce error to a minimum the most anterior point between the supraciliary eminences was taken but if this were present as an area the mid-vertical point of this area was taken as the glabella.

Sagittal contour. It is in obtaining this contour that considerable variations in the techniques of different workers are found. Benington stated that the skull was "adjusted so that the nasion, the bregma and the lambda lie in the same horizontal plane." That this is not always possible is shown by Tildesley's admission that once the plane was fixed it was not always followed. In fact she altered the position of the pointer so that it passed through the points of reference whether these were in the sagittal plane or not.

This method was also followed by Wagner but not by Wunderly who maintained the skull in the Frankfurt plane and obtained the sagittal contour at right angles to that. In the present study the midporial point was marked on the vault of the skull and the kubus then placed so that the skull lay with its right side down. With t pointer set to the height of the interpor point, the sagittal contour was then c tained.

It is felt that this method of tracing t sagittal contour is better than that adv cated by Tildesley, in that all three plan

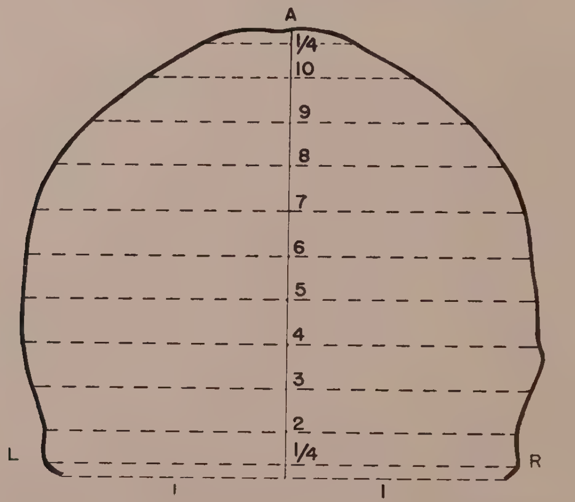


Fig. 1 Measurements taken on the vertical contour.

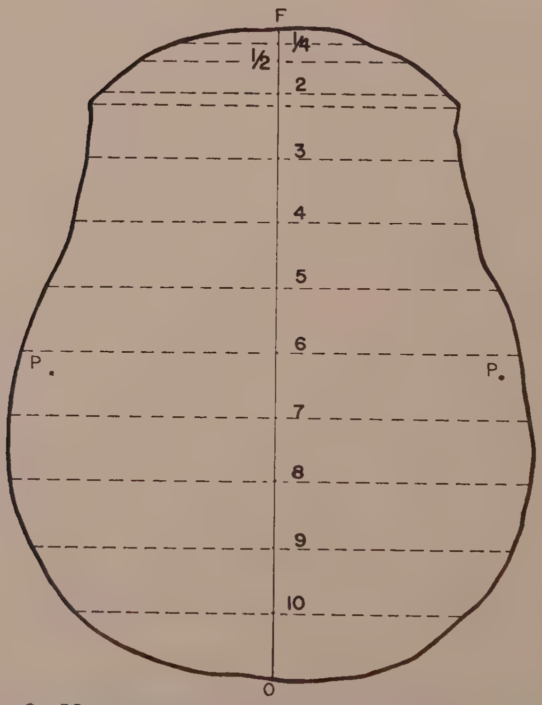


Fig. 2 Measurements taken on the horizontal contour.

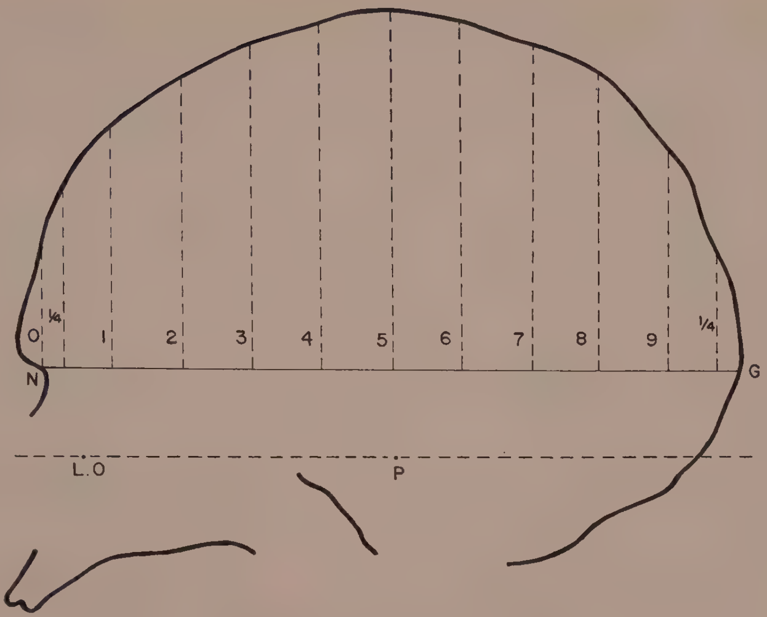


Fig. 3 Measurements taken on the sagittal contour.

are obtained with reference to the Frankfurt plane and mutually at right angles.

RESULTS

The tracings for the three contours were treated in accordance with the methods laid down by previous workers and the measurements taken are indicated in figures 1, 2 and 3.

It is important to remember that in the vertical contour, the line MA will not necessarily cut the vault at the apex. In the horizontal contour the line FO was drawn along the mid-porial plane and was not obtained by reference to any other bony landmarks.

DISCUSSION

In the vertical contours there is remarkable similarity to the results found by Wagner in his group from South Australia, there being a difference exceeding one millimeter in only two measurements. This was also apparent in the horizontal contours, in less than half the measurements there being a difference in excess of one millimeter but in no case did this exceed two millimeters. In the sagittal contour Wagner's figures for the South Australian group are consistently lower than those in this series, which lies in an intermediate position between Wagner's South Australian and Total Australian groups.

Keilor. In the vertical contours, the Keilor Skull (Wunderly, '43) exceeds the mean of the present measurements in all but one (A¼) and is close to or exceeds the maximum in 7 out of 13 measurements. In the horizontal contour Keilor again exceeds the mean in all but one measurement (10) but exceeds the maximum in only two measurements. In the sagittal contour Keilor exceeds the mean in all but three measurements (O, M¼, G¼) but does not exceed the maximum in any. It must be remembered, however, that the maximum quoted for each measurement is not found in any one skull and although there are several skulls of about the same size as Keilor, none exceeds it in all measurements. Keilor must be confirmed as a large skull although its measurements are not consistently beyond the range of variation for the males in this collection.

Sex differences. In the vertical contours the mean for the female was less than that for the male but the range in all

TABLE 1

Vertical contours

	Male						Female					
	Right			Left			Right			Left		
	Range	Mean	S.D.	Range	Mean	S.D.	Range	Mean	S.D.	Range	Mean	S.D.
1	51–63	57.1	2.1	51–63	57.1	2.1	47–60	54.0	2.3	47–60	54.0	2.3
M¼	55–65	59.4	2.3	55–66	59.7	2.2	50–63	56.2	2.4	51–63	56.7	2.4
2	53–66	59.6	2.6	53–68	59.9	2.7	48–63	56.9	2.6	53–62	57.4	2.2
3	56–68	61.8	2.7	57–68	61.9	2.4	49–67	59.1	2.8	55–65	59.8	2.6
4	58–69	63.7	2.6	58–69	63.5	2.4	51–68	61.0	3.1	56–69	61.6	2.6
5	58–69	63.6	2.6	57–69	63.3	2.4	51–69	60.8	2.9	56–69	61.4	2.6
6	56–68	62.3	2.8	57–68	62.4	2.4	50–66	59.3	2.8	54–69	60.1	2.6
7	52–66	60.0	3.0	54–69	60.4	2.7	50–66	57.0	2.8	53–67	58.1	2.6
8	44–62	55.4	3.2	50–62	55.5	2.7	46–61	53.1	2.9	49–64	54.0	2.8
9	39–55	46.4	2.9	40–53	46.0	2.7	33–52	44.7	3.1	39–56	45.1	2.8
10	21–40	31.3	2.9	25–37	31.3	2.6	21–38	30.2	3.1	23–40	31.3	2.7
A¼	9–23	15.7	2.7	11–23	16.8	2.6	7–24	14.6	2.9	11–25	17.0	2.4
M.A.	101–118:110.8:3.8						99–116:105.8:3.6					

TABLE 2

Horizontal contours

	Male						Female					
	Right			Left			Right			Left		
	Range	Mean	S.D.	Range	Mean	S.D.	Range	Mean	S.D.	Range	Mean	S.D.
F¼	13–36	24.8	4.5	17–39	25.0	4.7	18–34	24.9	4.0	16–37	25.7	4.3
F½	22–48	37.5	4.6	29–47	38.1	4.2	25–47	36.9	3.7	23–47	36.9	4.0
2	41–58	48.6	3.4	41–57	49.0	3.1	40–60	46.9	3.0	41–57	46.9	2.9
3	41–53	46.9	2.5	42–54	47.0	2.6	40–53	46.0	2.5	42–52	46.5	2.1
4	47–57	51.5	2.3	46–57	51.6	2.6	43–57	49.6	2.8	45–55	50.3	2.2
5	52–65	58.8	2.8	46–64	57.9	2.9	49–65	56.6	3.0	51–63	56.0	2.7
6	59–69	64.0	2.6	57–68	62.3	2.4	54–67	60.4	2.7	52–70	61.6	2.8
7	59–71	65.6	2.6	58–70	63.9	2.5	53–69	63.0	2.7	57–69	61.8	2.6
8	57–69	63.0	2.6	57–70	62.0	2.4	52–66	60.2	2.5	55–68	59.6	2.6
9	51–63	56.5	2.5	49–64	56.5	2.6	45–60	53.3	2.7	49–62	53.4	2.6
10	37–52	43.9	2.6	37–52	44.1	2.4	36–49	41.3	2.5	37–51	41.7	2.6
F.O.	171–200:185:5.9						165–189:177:5.2					

cases showed a considerable overlap. In the horizontal contours the mean for the female exceeded that for the male in one measurement (F¼) but in all others the male was greater. There is again a considerable overlap in the range of variation.

In the sagittal contour one measurement in the female exceeded that for the male (O) but in the remainder the male was the greater. The overlap in the range of variation was considerable.

TABLE 3

Sagittal contours

	Male			Female		
	Range	Mean	S.D.	Range	Mean	S.D.
N–G	167–199	182.6	5.7	165–188	176.0	4.6
0	15–45	27.7	6.6	15–43	27.8	6.2
N¼	23–54	38.7	6.3	26–52	38.9	5.8
1	45–70	57.8	4.6	46–72	56.2	4.3
2	59–82	70.2	4.4	60–81	67.6	4.0
3	67–91	77.8	4.8	67–85	74.2	3.8
4	68–96	81.9	4.7	70–90	78.0	3.9
5	68–97	83.2	4.7	70–92	79.3	4.0
6	71–95	81.9	4.4	70–92	78.4	4.0
7	64–90	77.3	4.6	65–86	74.2	4.1
8	52–81	67.9	5.2	52–76	64.5	4.4
9	29–68	48.3	5.9	33–56	44.7	4.9
G¼	12–47	23.2	5.9	9–44	21.2	6.1

TABLE 4

Vertical contours

	Male			Female		
	Left greater	Equal	Right greater	Left greater	Equal	Right greater
M¼	37	43	21	48	38	15
2	40	32	29	39	38	24
3	35	25	41	46	28	27
4	35	24	42	50	23	28
5	36	15	50	49	21	31
6	42	18	41	50	20	31
7	45	17	39	54	18	30
8	37	16	48	52	17	32
9	32	17	52	47	13	41
10	50	17	34	57	10	34
A¼	55	14	32	74	4	23

TABLE 5

Horizontal contours

	Male			Female		
	Left greater	Equal	Right greater	Left greater	Equal	Right greater
F¼	46	10	45	53	7	41
F½	51	15	35	48	12	41
2	40	5	56	50	8	42
3	43	11	47	55	14	32
4	40	13	48	58	14	29
5	28	10	63	32	20	49
6	13	16	72	22	14	65
7	16	12	73	24	12	65
8	23	13	64	32	15	54
9	41	17	42	41	16	44
10	50	13	38	49	17	35

It is interesting that both the measurements in which the mean for the female was the greater were the most anterior measurements taken.

Asymmetry. If each skull is perfectly symmetrical with reference to the poria the right and left sides for each measurement will always be equal. It would, however, be surprising if such were the case and tables 4 and 5 show the results.

These tables show the number of cases for each measurement in which there was a difference, but not the degree of such difference. The frequency distribution of such difference is shown in figures 4 and 5 where those showing a greater measure-

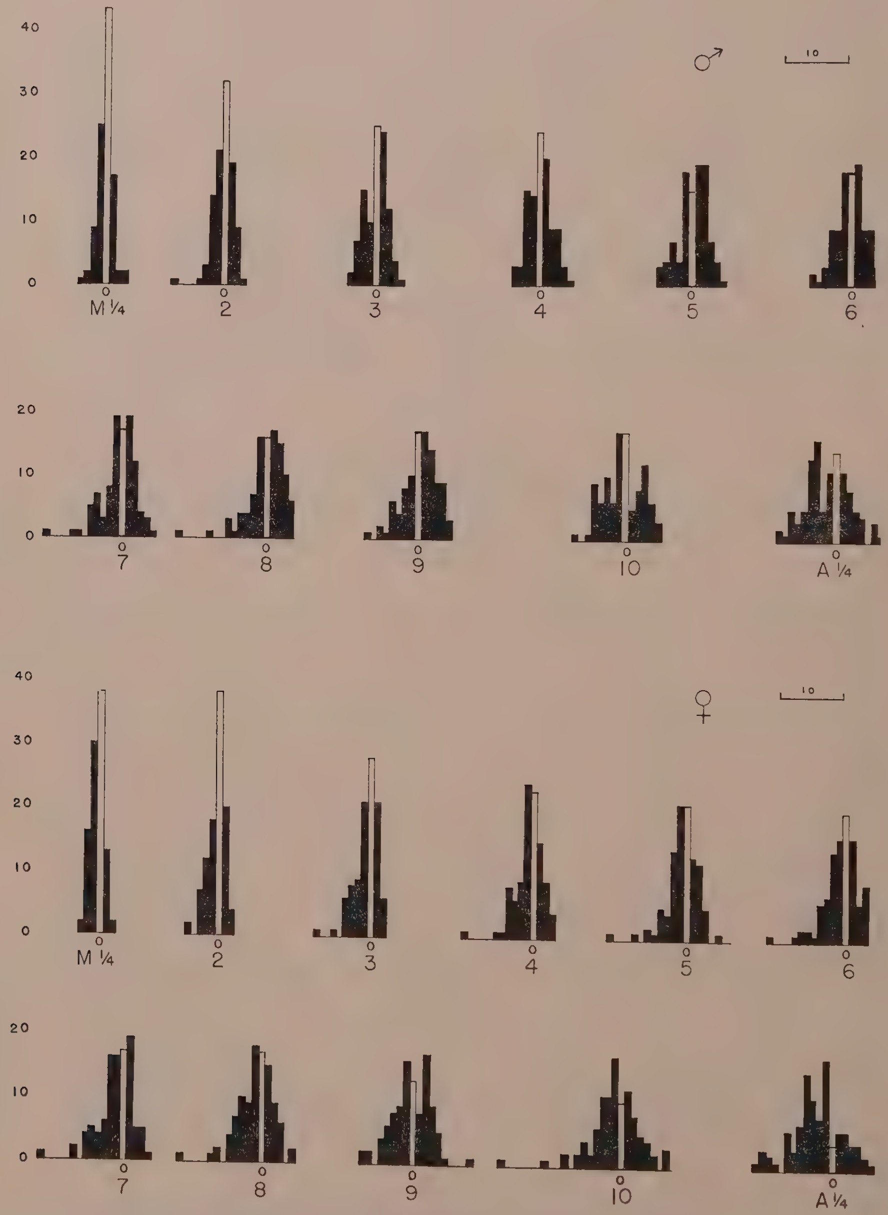


Fig. 4 Frequency distribution of the lateral differences in the vertical contour.

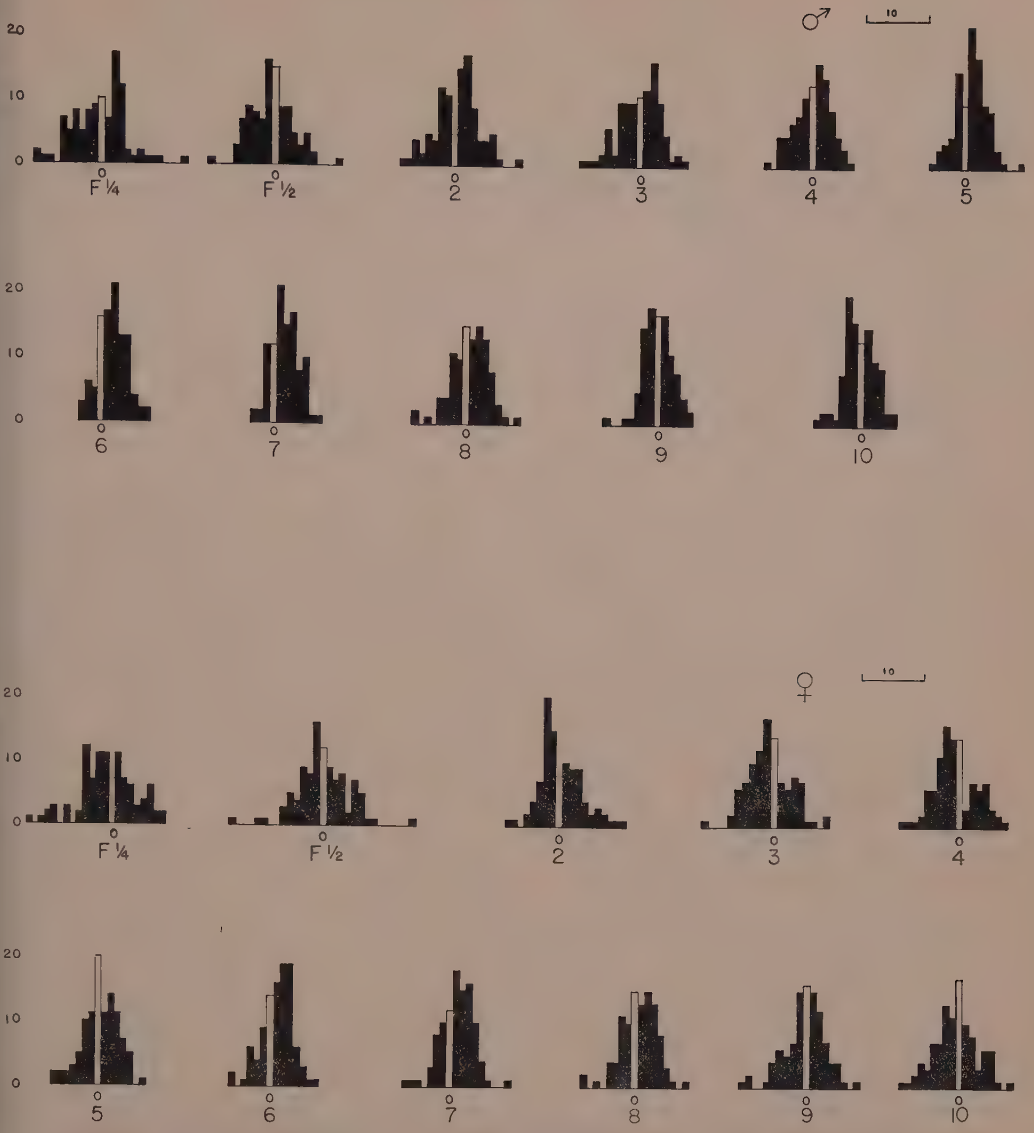


Fig. 5 Frequency distribution of the lateral differences in the horizontal contour.

ent on the left side are to the left of zero nd those with a greater measurement on ne right side to the right of zero.

SUMMARY

1. Contour tracings in the vertical, horiontal and sagittal planes were made on 01 male and 101 female Australian Aboiginal skulls.

2. Measurements were made on these racings in accordance with the principles utlined by previous workers.

3. Comparisons have been instituted with Wagner's work on Australian skulls and also with Wunderly's results on the Keilor skull.

4. An indication of the asymmetry of the skulls has been given.

ACKNOWLEDGMENTS

I would like to express my thanks to Professor Sunderland for his encouragement during this study and also to Mr.

A. C. Bakker for his assistance with the calculations.

LITERATURE CITED

Benington, R. C. 1911 Cranial type contours. Biometrika, *8:* 123–201.

Buxton, L. H. D., and G. M. Morant 1933 The essential craniological technique. Roy. Anthrop. Inst. Great Brit. and Ireland, *62:* 19–47.

Sunderland, S., and L. J. Ray 1959 A note on the Murray Black Collection of Australian aboriginal skeletons. Proc. Roy. Soc. Victori *71:* 45–48.

Tildesley, M. L. 1921 A first study of th Burmese skull. Biometrika, *13:* 176–262.

Wagner, K. 1937 The craniology of the Ocean races. Skrifter Utgitt Av det Norske Videnskap Akademi 1 Oslo.

Wunderly, J. 1943 The Keilor fossil skul Anatomical description. Mem. Nat. Mus., Me bourne, *13:* 57–69.

Book Reviews

THE PUERTO RICAN POPULATION. A Study in Human Biology. By Frederick P. Thieme. 156 pp., 138 tables, 76 graphs. Anthropological Papers, Museum of Anthropology, University of Michigan, Ann Arbor, 1959.

Studies broadly concerned with relating biological man to the major facets of his environment while controlling ethnic and other factors are sufficiently rare to be considered pioneering researches. As a pioneering study, Thieme's biological survey of the Puerto Rican people is the more remarkable because it was carried out over 12 years ago when the trend toward integrated human studies was just getting under way. Yet the study date of 1948 also precludes the newer nutritional, radiographic, body composition, and serological techniques so fruitfully used in more recent studies. Nevertheless, Thieme has reached some very important and clear-cut conclusions which bear witness to excellent concept of problem, sampling, and analysis, and to techniques and methods mostly well suited to their tasks.

The Puerto Rican sample consists of 3,562 adults (1913 males, 1649 females) drawn in proportion to the distribution of the total population of 2,211,000. In addition to the anthropometry, the Puerto Rican Department of Public Health provided individual interview data on diet, blood chemistry, physiology, and intestinal parasite studies. All these data are sorted into 7 ecological or geographic regions, 3 ethnic categories, and 4 gross nutritional classes. With the foregoing as background, some of the important conclusions are as follows. Racially the Puerto Ricans are made up of Negro and White elements, to an extent intermixed but at the same time kept partly separate by assortative phenotypic mating. Negroids are more concentrated on the coast, particularly in the northeast, while inland areas are more White. Blood genes B and R_o (cDe) are higher in frequency in the more Negroid regions, but only R_o and skin color bear significant χ^2 associations. Higher incidence of shovel-shaped incisors in the older and more White Puerto Ricans of the inland regions probably bears witness to greater yesteryear admixture with Indian aborigines. Within the same ecological setting, Whites are small in body size as compared with their parental population, but the Negroids show no such reduction. The only clue offered as explanation of this size differential is the somewhat better dietaries of the few Negroid families in a supplementary study of food intake in 36 families spread over 6 regions. This is rather shaky evidence, and an explanation in terms of greater body size potential for Negroes in hot climates (C. S. Coon, The American Naturalist, *89:* 263, 1955) would seem preferable.

Nutritional status is considered to be the major cause of anthropometric variability, even over race. But nutrition appears to have differential effects on different bodily segments—the greatest diminution in the poorer nutritional classes being in trunk height, and the least in lower arm length. The latter may be affected by the racial factor. It would have been interesting if the anthropometry had included lower leg measurements which might have shown high nutritional differential. And the various girths could well have been given the logarithmic treatment, since, as Brozek and others have suggested, they should show strong nutritional differences. Nutrition is probably the most important factor influencing dental health, although it is strange that relatively superior nutrition appears to increase resistance to caries in anterior teeth but decrease it in posterior teeth. These close relationships of nutrition to phenotype are particularly remarkable in view of the grossness of the nutritional classes abstracted from Lydia Roberts' survey and the quite risky use of the interview to determine class. In Roberts' study the use of milk intake as one of the important determinants of nutritional class seems rather at odds with Latin American food habits. And the supplementary 36 family food intake study covering 6 ecological regions is admittedly an inadequate sample, and could be very misleading. Intake of nutrients in this supplementary study are gauged by NRC standards, whereas the somewhat lower INCAP requirements are more realistic for Latin Americans. Presumably the percentages of the NRC standards that were attained by the Puerto Rican families were adjusted for sex, age, body weight, degree of activity, and ambient temperature, but it is not so stated.

The helminth and protozoan rate is high at 84% in 961 subjects, and is not significantly related to race, nutritional status, physiology or blood chemistry except for lower eosinophil counts in hookworn positives. Part of the lack of association may be due to the fact that adults usually have "made peace" with their unwelcome guests; part may be attributed to the necessarily gross groupings of helminth and protozoan positives and negatives, and some varieties of both parasites have clinically inconsequential effects under most any circumstances upon their hosts. White cell counts are lower in individuals of marked Negro ancestry, suggesting reduced foci of infections. Yet the lower hemoglobin levels in the more Negroid groups, as well as the lower nutritional categories, make it apparent that there is some unknown and possibly epidemiological factor in operation.

PTC testings were done with actual crystals and hence give no indication of taste thresholds. Non-tasters ran 13.3% in males, 10.3% in females, and hence are roughly intermediate between the incidences for Spanish Whites and West African Negroes. The ABO and Rh blood systems of the Puerto Ricans have been reported on elsewhere in extenso (Am. Jour. Human Genetics, 4:2, pp. 94-112). Inconsistencies in testing resulted in discard of all 3,079 MN and 1,200 Rh determinations. This was the only major failure of the Puerto Rican survey, and has happened to a larger number of serological studies than is usually recognized.

In the reviewer's opinion, Thieme's survey of the Puerto Rican people is a real landmark in human biology, and its results assume an importance beyond major criticism. Anchored to this 1948 study, a resurvey in a few more years would pay rich scientific dividends resulting principally from the careful planning and execution of the basic study. As one who in the late 1940's was only thinking about integrated studies in human biology, the reviewer has nothing but admiration for Thieme and his coworkers who took their thoughts into the field situation and accomplished signally successful research.

Marshall T. Newman
Division of Physical Anthropology
U. S. National Museum

CONTRIBUTIONS TO THE PHYSICAL ANTHROPOLOGY OF THE SOVIET UNION. By V. V. Bunak, G. F. Debets and M. G. Levin. Russian Translation Series of the Peabody Museum of Archaeology and Ethnology, Harvard University, Vol. I, No. 2. 192 pp., 73 tables, 5 maps. Cambridge, Mass. $4.50.

The 14 essays in this collection were furnished by the courtesy of Dr. G. F. Debets to Dr. Henry Field in complementation of the latter's publications in the same field. Despite the statement of authorship, however, the 8 additional "contributors" turn out to be co-authors, as the table of contents shows:

I. Anthropological Composition of the Population of the Caucasus: V. V. Bunak.

II. Craniology of the Caucasus: M. G. Abdushelishvili.

III. Preliminary Data on the Anthroological Investigations of the Georgian eople: A. N. Natishvili and M. G. Abushelishvili.

IV. Contributions to the Anthropology of e Georgian People: A. N. Natishvili and . G. Abdushelishvili.

V. Contribution to the Paleoanthropolgy of the Samthavro Graves: M. G. Abduhelishvili.

VI. Anthropological Investigations in aghestan: G. F. Debets.

VII. Some Material on the Anthropology the Nationalities of Daghestan: N. N. iklashevskaia.

VIII. Anthropology of the Avars: M. S. kimova and M. A. Bulatova.

IX. Anthropological Type of the Lezhians: M. S. Akimova.

X. The Eastern Kazakhstan Expedition, 952: S. S. Chernikov.

XI. Method and Program of Study of escriptive Characters in Anthropology nd the Necessity for their Revision: V. V. unak.

XII. Paleoanthropology of the Forest ribes of the Northern Altai: V. P. Alekeev.

XIII. South Siberian Anthropological ype: M. G. Levin.

XIV. Ethnic Composition of the Counries of Southwestern Asia: S. I. Bruk.

In greatly varying degrees these essays nd the tables that implement them cover e somatoscopy, somatometry, blood roups (mostly ABO, with pqr), dermatolyphics, and PTC reactivity of the living eoples; there are also ethnographic rearks and, occasionally, racial characteriations. The latter elaborate within what essentially the system of Yarkho. (For is system, consult Y. Y. Roginskiy and I. G. Levin, Osnovy Antropologii, Mosow, 1955; also V. V. Bunak, M. F. esturkh and Y. Y. Roginskiy, Antropolgiya, Moscow, 1941.) Articles II, V, X, II are archeological; II and XII supply raniometric data. The techniques are ssentially those of Martin.

The collection treats the peoples of the aucasus more copiously than any others; nd understandably, in regions heavy with thnic history there is the complicated roblem of recovering the stratifications at time has patterned. Some synthesis of linguistic, cultural-archeological, and bioanthropological data is attempted, as may be gleaned from the following (pp. 13–14):

"The diverse relations of the Caucasus with the southern provinces, including the western and eastern parts, furnish the key to the understanding of the very important and diversified characteristics of Caucasian languages, and for the presence of suffixes and prefixes in these languages . . . Ushakov assumes that, 'one should look in the toponyms of ancient Caucasia for features of similarity with Lydian-Aegean names,' as, for example, the name of the Kuban River . . . New archeological investigations furnish valuable material for the classification of ancient cultural relations of the various Caucasian provinces . . . The wide participation of the western element in the formation of ancient Caucasian types . . . was not less ancient than the influences of eastern centers of Asia Minor, Mesopotamia and Elam . . . the latter is more evident in the central highlands of Transcaucasia, for example, the painted pottery of Kzyl-Vank closely resembles the Elam motifs . . . Limiting oneself to these few facts, the most recent ethnographic, linguistic and archeological data agree fully and permit distinction of the ancient stages of the ethnogenesis of the Caucasus. The following facts have been established: 1. A common ancient ethnic sub-stratum extending throughout the greater part of the Caucasus, particularly in its western and central districts. Remnants of this stratum are preserved to the greatest extent in the present Adighe languages. 2. A somewhat distinct ancient stratum in the southeastern part of Transcaucasia, the linguistic traces of which have not been preserved up to the present or are not known. 3. The expansion of another cultural element, the pre-Georgian, in a later period (? Bronze Age) from the area between the Chorokh and Araks, which took root in western Transcaucasia and penetrated into parts of North Caucasus. 4. The migration of the final element, connected with eastern Anatolia, from the Van and Zagros areas to eastern Transcaucasia where it became established. Subsequent stages of cultural-historical interrelations already fall into the historical period . . . The picture of the most ancient ethnogenesis of the Caucasus, drawn in this manner, harmonizes fully with the results of anthropological analysis, and in confirming the correctness of it, obtains in this analysis an essential foundation. The most ancient general Caucasian stratum, the residual group of which is constituted by the present Adighe nationalities, was represented principally by the Pontic race, which is preserved even today with comparatively little change in the northwestern Caucasus. The Caspian race corresponds to the other ancient ethnic formation of the southeast, which is represented in the present Tats and Azerbaidzhanis, whose ethnic type is subjected to essential linguistic changes . . . (etc.) In the light of these data, the difference between the anthropological types of the Western and Eastern Caucasus becomes understandable, a difference which is preserved until the present time, particularly in the distribution of blood groups, in some cranial characters, in the shape of the face, and in the development of hair growth . . . At present, racial areas are considerably larger than ethnic, and cut across the boundaries of the latter in a most arbitrary manner. It cannot be otherwise, since the anthropological areas are much more stable, and reach further back into the distant past than the contemporary ethnic groups . . . It is clear that the basic strata which formed the conglomeration of Caucasian types . . . were subjected during centuries to diverse modifications, general as well as local facies, on the basis of the interrelation of basic elements and their development in isolated regions . . ." Tables of means fo several anthropometric quantities, bloo types, and modes of somatoscopic char acters, by ethnic groups, are assembled a evidence from various investigators.

Were Russian physical anthropolog familiar to Americans, a limited review o a limited selection of articles would ru small risk of promoting misappraisa Understandably, the samplings that con stitute this collection are a kind of short hand—they abbreviate their evidence an assume a good deal of antecedent back ground on the part of the reader. Non the less, the English-reader is liable t unease when confronted with hardly mor than means of metric and modes of quali tative characters of populations as th basis for conclusions about race. (Th cephalic index, for instance, carrie greater weight than it would to an Amer ican raciologist.) Assessments are ar rived at apparently without a considera tion of variance.

Still, it would be less than justice fo this review to permit the notion that Rus sian anthropologists are unaware tha theory, method, and technique of raciolog persist in an unsatisfactory condition. I article XI Bunak calls for greater precisio of somatoscopic techniques, a minimum set of 12 (8–10, at another place) somato scopic characters, more extensive an skillful use of photography.

The translating, though often stilted usually is adequate in conveying the mean ing of the Russian original.

Earl W. Count
Department of Anthropolog
Hamilton College
Clinton, New York

EVOLUTION OF THE SPEECH APPARATUS. By E. Lloyd du Brul. XII + 10
pp. Charles C Thomas, Springfield, Illinois. 1958. $4.75.

This little book contains numerous interesting and useful data, particularly respecting the interrelations of posture, cranial structure, and morphology of oral cavity, pharynx and larynx in a number o primates, lagomorphs, and a bird. To much of the book, however—in fact, abou one-third—is devoted to subjects which ave no real bearing on the problem—such s the origin of life, invertebrates, and irelevant aspects of various vertebrates.

The author believes that assumption f the erect, bipedal posture produced hanges in the cranio-pharyngeo-laryngeal pparatus which were the prime factors in ne evolution of speech. Strangely, except or presentation of cell counts for the nesencephalic nucleus of the trigeminal erve in a baboon, two chimpanzees, and a man, there is virtually no consideration of the brain. The reviewer, however, retains his conviction that the prime agent in the evolution of articulate speech has been the brain, particularly the cerebral cortex, and that the peripheral structures dealt with in this book have been essentially subservient and modificatory factors in that process.

WILLIAM L. STRAUS, JR.
Johns Hopkins University

PROCEEDINGS

of the

TWENTY-SEVENTH ANNUAL MEETING

OF

THE AMERICAN ASSOCIATION OF PHYSICAL ANTHROPOLOGISTS[1]

The 27th annual meeting of the Association was held in Cambridge, Massachusetts, Thursday through Saturday, 10–12 April, 1958, by invitation of the Department of Anthropology, Harvard University.

The affairs of the meeting were conducted in five sessions for scientific papers, the annual business meeting, the annual dinner, a Wenner-Gren supper conference, and a public lecture.

Following the annual dinner Thursday evening at the Hotel Continental a special program arranged by President Cobb on ''Physical anthropology and modern life'' presented four addresses: (1) ''The present, an hour of destiny for physical anthropology'' by President W. Montague Cobb. (2) ''Our giants of yesteryear'' by Wilton M. Krogman. (3) ''Functions of a teaching museum in modern society'' by William E. Scheele, Director of the Cleveland Museum of Natural History. (4) ''Physical anthropology and modern life'' by the Honorable David B. Karrick, Commissioner of the District of Columbia.

Following the Wenner-Gren supper at the Harvard Faculty Club Friday evening, the meeting moved to the Lamont Forum Room, Lamont Library, where a lively discussion on ''Current physical anthropology'' led by Sol Tax was opened with ''An appraisal of the status and needs of physical anthropology'' by Harold H. Plough.

---

[1] Prepared by J. N. Spuhler and type set in 1959; edited by T. D. Stewart in 1961.

For the first time in a number of years the Association sponsored a public lecture in connection with the annual meeting. T. D. Stewart, on this occasion, gave the first public presentation of the new Neanderthal skull from Iraq.

The Executive Committee of the Association held its regular annual meeting the evening of April 9, 1958. The business of the 27th annual meeting was conducted in two sessions:

BUSINESS MEETING, APRIL 10, 1958

The minutes of the 26th annual meeting were approved as printed (AJPA, n.s., 15: 421–453, 1957) with the proviso that attention be called to the error on page 429 regarding the date of the present meeting.

President Cobb announced the following appointments to committees: *Nominating Committee* (1959): (Record incomplete). *Viking Fund Award Committee* (1958–1959): Carleton S. Coon, F. Clark Howell, William W. Howells, Frederick S. Hulse, Wilton M. Krogman, E. Carl Sensenig, and Mildred Trotter, Chairman. *Auditing Committee* (1958): C. Loring Brace and James A. Gavan, Chairman. *Resolutions Committee* (1958): (Record incomplete). *Time and Place of Annual Meetings* (1959): Frederick S. Hulse, Neil C. Tappen, and Stanley M. Garn, Chairman.

Dr. W. W. Howells was appointed representative of the Association to the 5th International Congress of Prehistoric and Protohistoric Sciences, Hamburg, August 24–30, 1958. Dr. T. D. Stewart was appointed representative of the Association to the 33rd International Congress of Americanists, San José, Costa Rica, July 20–27, 1958. A representative of the Association to the Council of the AAAS for the term ending December 31, 1960, is to be appointed by the President.

The following new members were approved by the Executive Committee on April 9, 1958 and were elected to membership by unanimous vote:

George A. Agogino
Fred H. Allen, Jr.
William Barton
Hermann Bleibtreu
William E. Edwards
Donald H. Enlow
Elizabeth A. Fanning
Jaakko Kihlberg
Warren Kinzey
Robert A. Littlewood
Ross A. McFarland
Ernst Mayr
Peter H. Ovenburg
Demarest Polacheck
Francisco M. Salzano
Viken Sassouni
H. Wade Seaford
Howard W. Stoudt, Jr.
Sol Tax

We regret the loss by death of two members during the year: Prof. James W. Papez, Columbus, Ohio, and Dr. Elihu Leon Schuman, Lexington, Massachusetts.

The current membership of the Association is 438. There were 84 members in 1930, 153 in 1942, 300 in 1952, 404 in 1956, and 419 in 1957.

The Report of the Treasurer, and that of the Auditing Committee presented by James A. Gavan, were approved. The Treasurer noted that the Prudence Bond which provided a belated income during the fiscal year 1957–1958 of $2.30 was not included in the Treasurer's report for 1956–1957 because it had been redeemed prior to that fiscal year.

REPORT OF THE TREASURER — FISCAL YEAR 1957–1958

Operating Account:

Bank balance on April 1, 1957:		
Ann Arbor Bank, State Street Office		$4,749.65
Receipts:		
Annual membership dues including subscriptions	$2,163.00	
Annual membership dues without subscriptions	6.00	
Postage paid by foreign members	22.50	
American Society of Human Genetics, 1957 program	89.11	
Interest, Prudence Bond	2.30	2,282.91
		$7,032.56

Expenditures:		
Program, 1957	$ 146.78	
Program, 1958	91.67	
Postage	44.96	
Bank charge	.25	
Letterheads and envelopes	52.53	
Scroll for Dr. Fejos	50.00	
Check returned	7.42	
Wistar Institute, subscriptions and postage	1,566.00	1,959.61
Bank balance on April 1, 1958:		
Ann Arbor Bank, State Street Office		5,072.95
		$7,032.56

Investment Account:	
U. S. Savings Bonds, Series F, purchased June 9, 1949 (current redemption value $1,748.00), maturity value	$2,000.00
U. S. Savings Bonds, Series J, purchased May 8, 1956 (current redemption value $3,675.00), maturity value	5,000.00
	$7,000.00

Audited and found to be correct
April 10, 1958
James A. Gavan
C. Loring Brace
Auditing Committee

Respectfully submitted,
J. N. Spuhler, *Treasurer*
April 10, 1958

Russell W. Newman invited physical anthropologists travelling in the Boston area to visit the anthropological facilities of the Quartermaster Research and Development Command, Natick, Massachusetts.

The Report of the Editor was presented by William S. Laughlin. The current delay in publication of the AJPA is a result of installation of new press equipment at the printing plant of The Wistar Institute of Anatomy and Biology. It is the hope of the Institute and the Editor that publication of the Journal will soon return to its regular schedule. W. M. Krogman reported that Dr. Hilary Koprowski, the new Director of The Wistar Institute, and Dr. Edmond J. Farris, Director of Research, have indicated their continuing interest in the Journal. The association expressed its thanks to S. L. Washburn, the retiring Editor, for his devoted service and to The Wistar Institute for its long support of the Journal. In response to a query by Russell W. Newman, it was pointed out that income from advertising in the Journal is paid to The Wistar Institute and not to the Association. F. Clark Howell was appointed Associate Editor of the AJPA to replace T. D. McCown.

President Cobb reported that the Viking Fund Award Committee for 1957–58 had chosen Raymond A. Dart and that the medal had been presented to Prof. Dart at the annual dinner of the Wenner-Gren Foundation in New York on March 7, 1958 (see this Journal, n.s. vol. 16, no. 2, pp. 235–239). On this occasion the Association joined with the American Anthropological Association and the Society for American Archaeology to present a scroll to Dr. Paul Fejos, Director of Research, Wenner-Gren Foundation for Anthropological Research, in appreciation for his long devotion to anthropology and anthropologists.

President Cobb clarified the status and working procedures of the Viking Fund Award Committee of the AAPA. This committee is appointed by the President of the Association and usually consists of seven members including three former medalists with the most recent medalist who is a resident of the United States as Chairman. The Committee reports its nomination for the Viking Fund Award to the Executive Committee of the Association. The President of the Association then transmits the name of the nominee of the Association to the Foundation.

Russell W. Newman reported that the National Research Council Committee on Physical Anthropology is continuing its negotiations with the National Mail Order Association for a nation-wide anthropometric survey for clothing size information.

T. D. Stewart will make arrangements for a session on physical anthropology during the annual meeting of the American Anthropological Association, Shoreham Hotel, Washington, D. C., November 20–23, 1958.

President Cobb reported that the Executive Committee had rejected for the immediate future the suggestion that the

Executive Secretary of the American Anthropological Association keep the books and take care of the billing and mailing of the AAPA at a cost of one dollar per member per year. Until such time as the Secretary-Treasurer finds that he is overworked by association affairs it seems better to use the $400 required by the suggested arrangement for other Association needs. We are nonetheless appreciative of the kind offer of the AAA in this connection.

Paul T. Baker and William J. L. Felts reported on a possible successor to the defunct PA Newsletter. A survey conducted by members present at the meeting showed that all but four of 86 members were in favor of some form of news letter. A motion was carried to have a news letter for a one year trial. President Cobb appointed Baker and Felts editors of the Newsletter.

Stanley M. Garn reported for the Committee on Time and Place of Annual Meetings. The 28th annual meeting will be held in Madison, Wisconsin, probably on May 14–16, 1959, at the invitation of the University of Wisconsin. The 29th annual meeting will be held during the Spring of 1960 in Washington, D. C. on the invitation of Howard University.

The Report of the Resolutions Committee was moved accepted. The report expressed the gratitude of the Association to the officials and faculty of Department of Anthropology, Peabody Museum, the Lamont Library, and the Faculty Club of Harvard University for their part in making facilities and services available to us. It was resolved that the association give grateful thanks to Clyde Kluckhohn, chairman of the Department of Anthropology, Prof. John O. Brew, Director of the Peabody Museum, and Prof. William B. Ernst, Jr., Director of the Lamont Library, and to William W. Howells and Edward E. Hunt, Jr. for their contributions to a successful meeting. It was further resolved that the Association thank Dr. Paul Fejos and the Wenner-Gren Foundation for their continuing support of biological anthropology both here and abroad and Dr. Hilary Koprowski and Dr. Edmond J. Farris of the Wistar Institute for their friendly assistance to our Journal and Association. The Association extended its most sincere sympathies to the bereaved families of the late Prof. James W. Papez and Dr. Elihu L. Schuman.

The business meeting was recessed at 4:05 P.M. until 11:30 A.M. the following morning.

BUSINESS MEETING, APRIL 11, 1958

The second session of the annual business meeting was called to order by President Cobb. The resignation of J. N. Spuhler as Secretary-Treasurer was accepted; Spuhler plans to be in Japan during the first 10 months of 1959. Dr. Edward E. Hunt, Jr., Peabody Museum, Harvard University, Cambridge 38, Massachusetts, was elected Secretary-Treasurer to take office effective the Summer of 1958.

The following motion was passed unanimously:

"That the Secretary be instructed to write to Mr. William E. Scheele, Director of the Cleveland Museum of Natural History, expressing the appreciation of the AAPA for his informative after-dinner talk and especially his assurance that the Todd Collection of primate skeletons will be kept intact, maintained and made available for scientific research, since its further deterioration or disposal would be a scientific calamity. Furthermore, that the Secretary be instructed to emphasize that this collection is of particular importance to physical anthropologists and comparative anatomists for studies of morphological variations, owing to its unparalleled size and broad scope, and that it could not be duplicated under present conditions."

The scientific sessions of the meeting included the following papers:

1. *Serology and nomenclature of the blood groups, and their importance for physical anthropology.* Alexander S. Wiener, Office of the Chief Medical Examiner of New York City.

No abstract.

2. Blood grouping in anthropology. Technical aspects with particular reference to the field laboratory. Fred H. Allen, Jr., Blood Grouping Laboratory of Boston.

There are now more than 50 different human red-cell blood-group factors that can be tested for with specific antiserums. The majority of these should be used, if possible, in any work on previously untested populations. Not only is the anthropological value of the test much greater when many serums are used, but the new population may provide valuable data regarding the inheritance of the blood groups, particularly when whole families can be tested. The problem of reagents is so critical, and the technical difficulties are so formidable, that the tests should be undertaken only by an established laboratory.

In 1956 we set up a complete blood grouping laboratory in the Peruvian Andes at 10,000 feet, and tested over 500 Indians. There were some troubles that could have been avoided. The most serious problems were the distance from the home supplies, and the great expense of transporting and setting up the field laboratory. In spite of some real advantages of the field laboratory, it would usually be advisable to ship samples by air to the home laboratory.

3. Blood group systems in Latin American Indians. Marshall T. Newman, Division of Physical Anthropology, U. S. National Museum.

Comparisons of F. H. Allen's determinations on 8 blood group systems in 435 Vicos Quechua Indians with those of other Latin American series provides several clear-cut generalizations: (1) Blood type A was probably aboriginal in Latin America, and not wholly introduced by Europeans and others, because subtype A_2 is virtually lacking in 7 Indian series thus far tested. The A_2/A_1 ratio is about 1: 5 in Europeans and 1: 8 in Mestizos, but 1: 114 in these Latin American Indians — the same as in North America where most type A is considered aboriginal. In the northern continent the gene frequency of A is $> .04$ in relatively unmixed Indians, whereas south of the Mexican border it is $< .04$ and in South America appears restricted to the Andean area. The 11 Tropical Forest Indian series in eastern South America completely lack types A and B, as may have been the case in eastern North America as well. The hypothesis developed here is that gene A was carried by migrations from its center in western North America through Mexico and down the Andes. The coincidence of this distribution with the spread of high culture at the Formative level suggests that gene A was carried from Mexico by migrations to the Andean area 4,000–5,000 years ago. (2) The ratio of type B to A in 34 Latin American Indian series with both genes is at least one-third higher than in Europeans. This is more than can be explained by hybridization alone, especially since A was probably already present. Furthermore the highest B/A ratios in large and representative series are from areas of early and extensive colonization by Europeans. Since the Indian populations first receiving gene B have it in greatest relative proportions, there is a possibility of the same sort of selective action suggested by Birdsell for native Australians and in many other areas of the world where B seems to be a recent introduction. (3) In viewing the M N system, the highest and lowest M frequencies occur mostly in small series, suggesting errors of sample. Moreover, recalculation of gene frequencies by the probably more accurate $\sqrt{N}$ method clarifies the distribution of M frequencies and reveals that most Mexican and Middle American Indian series have a mean range of .74–.83, as in North America, but most South American Indians series have a lower mean range of .61–.74. (4) In the Rh system, all 9 Latin American Indian series have R_1 (CDe) frequencies over .50, while most North American Indians are less than .50. Exceptions are the Ute, ''Diegueño,'' and Pima close to the Mexican border. Inaccurate appraisals of gene R_0 (cDe) give it a 10% frequency in most Indians, whereas judging by the presence of the pure phenotype (ccDee) in only 5 Indian populations, R_0 may be frequently absent. Since neither ccDee nor ccddee has occurred in South American Indian series, it is impossible to differentiate R_0 from r among them.

4. The distribution of ABO blood group and secretor phenotypes in infertile couples and among infertile males. John Buettner-Janusch, S. J. Behrman and F. P. Thieme, University of Michigan.

Preliminary report of an extended study of infertility related to the ABO blood group phenotypes is presented in this paper. The first 82 infertile couples in the study are analyzed. Of the 82 infertile couples 74 are heterospecific with respect to the ABO blood groups. That is, the husband in the mating carries an ABO erythrocyte antigen that is not present in the female. The female, thus, is capable of producing a specific antibody for the erythrocyte antigen of the male or fetus. Of these 82 couples 74 are heterospecific and 8 were homospecific. Seven other couples in heterospecific matings, and who were ''delayed fertilities'' proved to have the following characteristics: there were 5 A males married to O females and 2 B males married to O females. These 7 matings had 9 children, all of blood group O. The frequencies of the ABO phenotypes in the couples were as follows: 33% A, 14% B, 30% O, and 23% AB. This is significantly different from the general population in the Detroit area. Secretor phenotypes were also tested. Of the 178 infertiles, 57% were non-secretors and 43% were secretors. The implications of these findings are discussed.

5. ABO blood types of 100 pre-Columbian American Indians of the north Alabama region. Michael Charney, Hackensack, N. J.

A series of 100 bones of Pre-Columbian American Indians of the North Alabama region were blood typed for the ABO factors using the Candela technique. Serum pools of human anti-A and anti-B were used at a working dilution of 1: 12 for each throughout the entire series. No loss of antibody titre was noted, which phenomenon happened in the work on the Pre-Aleut material of Candela when the switch was made from single donor sera to pooled samples. Serum was protected with aqueous merthiolate at 1: 1000 and all dilutions made with sterile physiological saline.

The bone material all came from vertebral bones and was ground to a fine powder for use. To two sterile tubes containing 0.3 grams of bone 0.75 cc of the diluted sera were added. Samples were refrigerated for from 15 to 24 hours and frequently agitated. After centrifugalization, the clear supernatant was tested for residual agglutination with fresh erythrocyte cells.

Results showed 10 specimens giving clear reactions for Type "A," all definitely prehistoric according to the archaeological evidence (5,000 yrs. old). Dr. Snow felt that the Shell Mound specimens perhaps did not lend themselves to dry bone typing possibly due to acid or bacterial condition of the mounds obscuring the blood cell reaction. However, two specimens out of twenty from one site gave definite reactions for Type A.

6. *Blood type frequencies among the Hupa of northwestern California.* Frederick S. Hulse, Department of Anthropology, University of Washington.

(Read by title.)

7. *A comparative study of bone densities.*[1] Mildred Trotter, George E. Broman,[2] and Roy R. Peterson, Department of Anatomy, Washington University School of Medicine.

The densities (weight/volume) of the lumbar vertebrae and femurs from 80 adult skeletons were determined. The skeletons were derived equally from American Whites and Negroes of both sexes, each group with a wide age range. Weight was taken of the bones in a dry, fat-free state. Volume of each series of lumbar vertebrae and of each femur was measured by displacement of millet seed. The reproducibility of this method was compared with that of the methods of water displacement, of weighing the bone under water, and of weighing it under water after steps had been taken to evacuate trapped air from the internal bone structure. The precision of the millet seed determination compared favorably with that by the most precise water method.

It was found that femurs are significantly more dense than lumbar vertebrae, that the vertebrae, but not the femurs, are significantly more dense in American Negroes than in American Whites, that in neither race is there a significant sex difference, and that the density of both series of bones (except vertebrae in the Negro male group) decreases significantly with age at approximately the same rate regardless of race or sex.

---

[1] Supported by grant A-1013, USPHS.
[2] Summer Research Fellow.

8. *Studies on the relations between the tensile strength of human bone and osteon number and size.*[1] F. Gaynor Evans, Department of Anatomy, Wayne State University.

Transverse sections of specimens of compact bone from adult human femurs and fibulas were studied by ordinary and polarized light. The number of osteones per square millimeter and the area (in sq. mm.) per osteon were related to the ultimate tensile strength, previously determined, of the specimen from which the section was obtained. A similar procedure was followed for the fragments of osteones in each section. Among the sections thus far analyzed those from the fibula are characterized by having a higher ultimate tensile strength (kg/mm^2)

and larger (mm²) but fewer osteones per square millimeter than do sections from femoral specimens. The fibular sections also have larger (mm²) and fewer fragments per square millimeter than do femoral sections. Polarized light studies reveal that the predominant direction of the collagen fibers in the fibular osteones and fragments is approximately parallel with the long axis of the bone and specimen from which the section was taken as well as with the direction of loading in the tensile strength tests. In the femoral sections the predominant direction of the collagen fibers was oblique or nearly perpendicular to the long axis of the bone and specimen and to the direction of loading. The methods used and the results obtained will be illustrated. The investigation is continuing.

---

[1] Supported by a Fulbright Research Scholarship to Italy (1956–57) and (in part) by a research grant (A-377 (C8)) from the National Institutes of Health.

9. The fluorescence of human bone as viewed under short wave ultra-violet rays. Thomas W. McKern, Environmental Protection Research Division, QM Research and Engineering Command, Natick, Massachusetts.

When most bone surfaces are exposed to short wave ultra-violet radiation, they react by reflecting a variety of colors. The wide range of color emission as well as the stable characteristics of these colors for the substances that emit them, is basis enough for attempting to apply these qualities to the segregation of commingled skeletal remains.

After demonstrating the results of U–V exposure on a large sample of skeletal material, it is suggested that short wave ultra-violet lamps can be used in some instances for the accurate sorting of commingled remains.

10. Bio-mechanical studies in skeletal organogenesis: Longitudinal compressive stress and the implanted immature long bone. James W. Monson and William J. L. Felts, Department of Anatomy, University of Minnesota.

No abstract.

11. The use of x-ray films of the hand and wrist as an aid in individual identification.[1] William Walter Greulich, Department of Anatomy, Stanford University School of Medicine.

As seen in the x-ray film, the various bones of the hand and wrist show individual differences in shape which are sufficient, in the aggregate, to distinguish the hand-film of one person from that of another. Beginning at the distal end of the radius and ulna and proceeding distally, the most useful of these features are: the size and shape of the styloid process of the ulna and the distal end of the radius; the shape of the individual carpal bones; the relative width of the cortex and the medullary cavity of the metacarpals; the individual differences in the outline of the inner margin of the cortex (i.e., the margin immediately adjacent to the medullary cavity); the differences in the shape of the individual phalanges; and, finally, the individual differences in the trabecular pattern of the various phalanges.

Our study of hand films which had been made on the same individuals at annual intervals over a long period of years disclosed that the features which we find useful in individual identification remain practically unchanged, at least during the period from early adolescence until well into the thirties, the age of the oldest man on whom such longitudinal data were available to us. There is no reason to believe that most, if not all, of these features do not persist throughout adult life.

On about 500 of the subjects whom we x-rayed, we were able to obtain films of both the right and left hands. We found that there is sufficient similarity in the shape of individual bones in the two hands of most individuals so that a person on whom only one hand-film had been made could in most cases be identified from a film of his other hand.

---

[1] Supported by funds from the United States Army Quartermaster Research and Development Command (Contract DA 19-129-QM-816).

12. A method of identification of war-dead by means of roentgenographic cephalometry.[1] Viken Sassouni, Graduate School of Medicine, University of Pennsylvania.

The problem posed by the Quartermaster Research and Development Command, United States Army, was: ''What are the five measurements in the head and face (as seen in the frontal and lateral x-ray films) which are the most variable, the least correlated, and the most reliable, that can be used for identification purposes? The mandible should not be included in more than one measurement. The test should be carried out on 500 adult males above eighteen years of age.''

This study was conducted at the Philadelphia Center for Research in Child Growth.

1. Four hundred and ninety-eight males were x-rayed twice with the Broadbent-Bolton roentgenographic cephalometer; the first set represents the ante-mortem films (AM) and the second set the post-mortem films (PM). Two hundred and forty-eight were x-rayed in Philadelphia; seventy at the Bolton Fund, Western Reserve University; one hundred and twenty at the University of Illinois; and one hundred and ten at the National Institutes of Health. They represent grossly a cross-section of young adult American males.

2. For various reasons but basically in order to obtain the greatest variability for the minimum error, and, at the same time, to avoid tracings, linear dimensions were selected as the method of measurement.

3. Twenty-four measurements were selected on the frontal film. Large error, low variations, and duplications eliminated sixteen of them. The remaining eight measurements are: frontal sinus breadth, facial height, bigonial, cranial height (mastoid-apex), incision height, bizygomatic, bimaxillary, and maximum cranial breadth.

4. Twenty-four measurements were selected on the lateral film. The remaining eight measurements are: height of the cranium 8 cm. posterior, 4 cm. posterior, just above, and 4 cm. anterior to center of the sella turcica; facial height (Na–Me); cranial length along Nasion-Sella, 4 cm. above, and 8 cm. above.

5. A table of correlation was computed among the sixteen selected measurements (eight frontals, eight laterals). From these sixteen the five best measurements in terms of high variability, low error, and low correlation were selected

by individual simultaneous computation. These five measurements are: length of cranium 4 cm. above Na–S, sinus breadth, total facial height, bigonial and bizygomatic breadths. They are the most characteristic of the individuality of an adult male.

6. Since four of the five selected measurements are from the frontal film, and in order to realize a 50% economy, an attempt was made to use only the frontal film for purposes of identification.

7. A test was made to identify one hundred PM frontal films from 498 AM films. A special routine was written to permit location and neutralization of accidental errors. The test was conducted on a Univac machine. It took ten seconds for the Univac machine to locate the correct film out of 498 possibilities. Direct identification was made on 97%; 3% could be identified by direct comparison with the remaining films. It can be stated, therefore, that the test of identification was 100% successful.

8. Suggestions were made which, if adopted, may lead to: increasing the standardization of the entire process; decreasing the errors; creating a mobile roentgenographic unit; initiating a longitudinal study of the growth of head and face in adults.

9. In conclusion, identification can be realized with 100% accuracy. At the same time, the roentgenographic films gathered will constitute for medical and dental health units an invaluable source of information on one of the most vital areas of the human body.

---

[1] Supported by contract no. DA-19-129-QM-739, Mod. no. 1, Quartermaster Research and Development Command, U. S. Army.

13. A comparative study of the sequence and time of appearance of maturity indicators in the hand in White, Negro and Chinese children in the U. S. William M. Bass III, Graduate School of Medicine, University of Pennsylvania.

Hand x-ray films of 484 Negro school children, 242 males and 242 females; 85 Chinese-American school children, and 128 white American school children, 59 males and 69 females, were examined for differential skeletal maturation in relation to race. Answers to a two-fold problem were sought:

I. Are there racial (genetic) differences in the skeletal age?
II. Can American Atlases (Todd, Greulich-Pyle, etc.) be used to assess other groups (ethnic and/or racial)?

The Negro sample is drawn from two studies, the first by Richard A. Platt on 243 Negro school children, 143 from Philadelphia and 100 from Florida, ranging in age from 4: 6 to 14: 5. The t-test was used to determine whether there were significant differences between skeletal ages and chronological ages. The results indicate that skeletal ages were not significantly advanced or retarded with respect to chronological ages.

The second Negro sample was based on hand x-ray films of 241 Philadelphia Negro school children. Mean deviations between chronological age and calculated skeletal age are felt, on the basis of the inspectional method, to fall within limits of normal variation for white children. Hand x-ray films of 85 Chinese-American school children have more irregularities than Whites or Negroes but the sample is too small for other valid conclusions.

On the basis of the data presented, it is felt that the skeletal maturation of American Negro children closely approximates that of American white children. The relation is so close that the establishment of separate skeletal age norms for American Negro children does not seem necessary.

---

[1] The material on Whites, Negroes, and Chinese is mainly from the files of the *Growth Center*, and was gathered while we were aided by U.S.P.H.S. grants D-87 to D-87(C7).

14. Trends in the evolution of the human neural skull: implications of an experimental study. Richard W. Young, Department of Anatomy, Columbia University.

In order to test the relationship between intracranial contents and growth of cranial bones, an experimental situation was sought in which the skull vault could be studied following the increase or decrease in volume of intracranial tissues. It was found that experimental hydrocephaly and microcephaly were adequate tools for this purpose.

Hydrocephaly was induced in kittens by intracisternal injections of a lampblack suspension (Weed, '22). Similar injections of a kaolin suspension (Griffith & Roberts, '38) were sufficient to produce hydrocephaly in rats. Cranial contents were reduced in rats by puncturing the temporal region with a fine glass pipette connected to a water aspirator and withdrawing neural tissue by suction. Growth was allowed to continue for variable periods, after which the animals were sacrificed.

Preliminary results indicate that the skull vaults of the small-brained animals were smaller, lower, flatter and thicker, with more mature sutures than the crania of large-vaulted littermates. The skulls of the latter group were not only larger and thinner, but also more globular in shape.

The changes observed in the vault when intracranial contents were increased are similar to those which are believed by some students of human evolution to characterize the development of the hominid cranium during the Pleistocene. Consequently, these experiments support Weidenreich's suggestion ('41, '43) that an increase in brain volume may have been an important morphogenetic agent in the evolution of the human neural skull.

On the other hand, a great many other factors are also known which modify the growth of cranial bones. These should be given due consideration in the interpretation of cranial form.

15. Stereotaxic methods in craniocerebral measurement. H. Hamlin, Harvard Medical School.

No abstract.

16. A critical analysis of method in dental eruption studies. Albert A. Dahlberg, Renée M. Menegaz-Bock, Zoller Memorial Dental Clinic and Department of Anthropology, University of Chicago.

Population studies of tooth emergence have been subject to methods of data collection and analysis which are not comparable. The advisability of standardizing methods is discussed in order to make results more useful to research workers and clinicians.

Consideration of sampling and measurement problems leads to the conclusion that cross-sectional studies are to be preferred over longitudinal studies of tooth emergence, primarily because the sampling can include much larger numbers of cases than is practical in longitudinal studies. Secondly, longitudinal studies, when compared to cross-sectional studies on the same populations, show consistently higher (older) estimates of eruption time. This is construed as the result of a bias in the longitudinal studies toward later estimation. In longitudinal studies the age at which the tooth is observed is grouped to the nearest class midpoint. Some of the observed ages of tooth eruption are added to, and others subtracted from. More properly, all of the ages ought to have subtracted from them one half of the examination interval, assuming uniformly distributed eruption during that period, because the observer always sees the tooth after it has erupted. This correction appears not to have been made in the longitudinal studies in the literature.

As measures of central tendency, the mean and the median estimate the same parameter if the distribution is normal. There is some evidence, however, that a few late emerging teeth tend to have a slight extension of the upper tail of the eruption distribution. Some of this may be due to delayed loss of deciduous teeth, extraction, or delayed puberty. The proportion of children so affected is probably small, one or two percent. The distribution for the remainder of the children appears normal.

From our experience in determining the eruption times of Pima Indians and comparing the results with other studies, we have the following suggestions: (1) For racial comparisons, fit the normal curve by probit analysis, censoring the distributions of the later teeth at about twelve years of age. Use the resulting median to compare groups and publish medians, standard deviations and standard errors of the medians. These figures reflect best 98–99 percent of typical cases. (2) For orthodontics and forensic anthropometry, fit the normal function to cross-sectional data to determine the probabilities that a tooth will have entered by a given age. For later teeth, censor the distribution and fit the normal function up to, perhaps, the 95 percent point. Fit the remainder of the curve empirically from whatever data is available. Publish the results as probability tables which will be directly useful to these workers. (3) The analysis of cross-sectional data for publication should be based on a maximum likelihood solution using a suitable distribution function (normal, logistic, *etc.*). Finney's probit method is convenient. For informal analysis, fitting distributions by eye using normal probability paper is recommended.

17. Natural head position and prognathism. Coenraad F. A. Moorrees, and Martin R. Kean, Forsyth Dental Infirmary for Children, Boston.

The head is in its natural position when the visual axis is horizontal, according to Broca (1862). A method was developed to take cephalometric radiographs in natural head position, the eyes looking in a mirror, the head unsupported, but self-aligned to keep the distance between the midsagittal plane and film constant. A true vertical wire was placed directly in front of the cassette and reproduced on each film permitted registration of head position in space. Natural head position was remarkably constant in a group of 61 female students, examined twice with a one-week interval. The standard deviation of head position determined by measuring the angles sella turcica-nasion and the vertical on each set of radiographs is 1.54 degrees, and the correlation coefficients of the angles SNV at the two examinations is $+0.85 \pm 0.04$. The biologic variation of various reference lines in the cranium (S.D. ranging from 3.55 to 6.69 degrees) was greater than the variation in registration of head position ($P < 0.01$). The line of reference used in the analysis of cephalograms should reflect the orientation of the head in space. This can be accomplished only by a reference line outside the head. A vertical extracranial line was shown to be preferable for the study of prognathism to the routine use of such intracranial lines as the Frankfort Horizontal or sella turcica-nasion line.

18. *Study of dentofacial morphology in esthetic occidental Whites based upon anthropologic racial criteria, employing cephalometric radiography, photography, and casts of the dentition.* Edward A. Lusterman, Fort Greene Health Center, New York City.

This study was suggested by the fact that classification, diagnosis, and treatment planning in clinical orthodontics are intimately concerned with facial esthetics. The purpose of the study is to determine whether, in subjects with clinically excellent dentitions and good facial esthetics, definitive relationships can be established anthropologically, through seriation of subjects based on racial classification.

The material consisted of 125 girls, between 12 and 18 years of age, selected from New York City schools, who conformed to the requirements of excellent occlusion and orthognathous faces. These were seriated in accordance with anthropologic standards, employing a table based upon Hooton's use of non-adaptive physical criteria in racial determination. The results of this seriation are as follows: Armenoid 23, Alpine 43, Mediterranean 27, Nordic 32. Cephalometric roentgenology was employed to correlate hard and soft tissue detail, making possible a study of the patterns of the facial skeleton, the denture, and the physiognomy. Oriented profile and full-face photographs were taken. Casts of the teeth were made to study and classify types of arch form.

At the time of this undertaking (1952) studies in cephalometrics were in the main confined to the skeleton and denture and failed to take into account considerations of soft tissue relationships, i.e., the nose-lips-chin components. The validity of Schadow's canon, as employed by the plastic surgeon Maliniac, was also tested in the cephalometric appraisal. Orthodontic intervention may often be a great factor in the correction of morphological and postural aberrations, but it is essential to recognize that while patterns may be changed, the necessity to distinguish racial types should be a paramount consideration.

19. Studies in tooth formation.[1] S. M. Garn, A. B. Lewis, K. Koski and D. L. Polacheck, Fels Research Institute, Antioch College.

Despite the vast number of dental radiographs taken in the past 50 years little definite information is available on tooth formation. The commonly-quoted Logan-Kronfeld norms fall short of the 5th and 95th-percentile range for contemporary Whites: standard pictorial charts make no allowances for sex differences. Actually, the dimorphism in tooth formation is 3–5% comparable in magnitude to the sex difference in eruption.

Correlating size, weight and measures of somatic and sexual maturation with various stages of calcification and eruption, two clusters emerge. Cusp, crown and root formation are positively but slightly correlated with size and maturity status. However, movement of the teeth from the alveolus to the occlusal level is moderately correlated with sexual maturation. These findings are consistent with clinical and experimental findings on the determinants of "eruption."

Twin and sibling studies suggest that the time of formation may be genetically determined in part, with correlations ranging from 0.92 for monozygotic twins down to 0.30 for siblings. These data, together with the low correlations between general maturity and tooth formation lead one to wonder whether tooth formation has become earlier in recent years.

Besides the desirability of further information on Whites, there is a need for tooth-formation data on non-Whites, who tend to be earlier in gingival eruption. Such data would be useful both for human identification and in the study of fossil man. Finally, data on tooth formation in the infra-human primates would permit comparisons of the sequences of tooth formation in other primates and man.

---

[1] Supported in part under grant no. M.1260 from the National Institutes of Health.

The following four papers were read in the Wenner-Gren Conference on Current Physical Anthropology:

20. Aspect of current physical anthropology: Method and theory. William S. Laughlin, Department of Sociology and Anthropology, University of Wisconsin.

No abstract.

21. Some experimental approaches in physical anthropology. Fred P. Thieme, Department of Anthropology, University of Michigan.

No abstract.

22. Anatomy and physical anthropology: Common concerns. G. E. Erikson, Department of Anatomy, Harvard Medical School.

No abstract.

23. Man as a domestic animal. J. N. Spuhler, Departments of Anthropology and of Human Genetics, University of Michigan.

No abstract.

24. The restored Shanidar I skull from northern Iraq. T. D. Stewart, U. S. National Museum, Washington, D. C.

In the spring of 1957 Ralph Solecki reported from Iraq the discovery of the first adult skeleton from the Mousterian cultural level of the Shanidar cave. This skeleton was covered with rocks which had fallen from the roof of the cave and hence was considerably damaged, but the skull, although broken into many pieces, was nearly complete. The antiquity of the specimen is estimated to be 45,000 years.

Subsequently Dr. Solecki nominated me to restore and study the Shanidar I skeleton. Thanks to a cooperative arrangement between the American Philosophical Society, the Iraq Government and the Smithsonian Institution I was able to go to Baghdad early in October and to spend 3 months there on the project.

On reaching the Iraq Museum in Baghdad, where the specimen is kept, I found that the skull had already been partly assembled by George Maranjian and that the post-cranial bones had been cleaned by workers in the laboratory. The skull had been put together and painted with a water glue and the other bones had been painted with a plastic glue. Thus I had to take the skull apart again and clean the fragments. The process of reassembling the skull fragments and restoring missing parts took nearly 2 months. Another month was required to make casts of the skull and jaw and to take photographs, drawings, x-rays, etc. At intervals during this time the better preserved post-cranial bones were cleaned restored, and cast. Some post-cranial parts had to be left for future study.

In this first public presentation of the results only the skull will be considered in detail. Emphasis will be placed on the factors which determine the quality of the restoration. This is important because the question arises as to the extent to which the form and size of the posterior vault is a product of the restoration. Otherwise it is clear that the skull, especially in the face, has many primitive features. The persistence of such a primitive type to a time only 45,000 years ago is perhaps the most significant thing about the discovery.

Shanidar I probably was a male and seems to have been over 40 at the time of death; he was tall for a Neanderthaler (at least 5′ 8″) and had a large brain (1610 cc). Casts of the skull and jaw will be exhibited.

25. Race, physique, and disease: Recent research in acne, cancer, hypertension, and polycythemia vera. Albert Damon, Harvard School of Public Health.

With infections declining in importance, those diseases in which host factors predominate are now the leading causes of death and disability in this country. Some of the host factors receiving reviewed medical attention, such as race, physique, and blood groups, also concern the anthropologist. Recent longitudinal studies in England and the United States confirm Hippocrates' notion of the ''phthisic'' habitus. Among large numbers of clinically and radiographically normal subjects, tall thin ones developed later tuberculosis far more often than short fat ones.

Acne vulgaris is said to be especially frequent or severe among brunets, Southern Europeans, or — according to various authors — mesomorphic or heavy men. Among 400 consecutive white soldiers at Army induction, no relationships were found between acne, and ancestry, complexion, or physique.

With Dr. G. A. Perera, the physique of 120 patients with essential hypertension was studied at the Presbyterian Hospital in New York City. The patients were evenly divided by sex and form of hypertension, benign or malignant. Ages were comparable, and only stable weights, unaffected by disease, were used. Men with the two forms of hypertension did not differ in height, weight, or the height $\sqrt[3]{\text{weight}}$ index. Women with malignant hypertension were significantly leaner ($p < 0.0001$) than those with the benign form. The latter were significantly stockier, and those with malignant hypertension leaner than women from the same hospital population without known disease. Since the benign form of hypertension is some 20 times commoner than the malignant, these observations and those by others tend to confirm the Hippocratic ''apoplectic'' habitus.

Polycythemia vera is said to be relatively rare among Negroes and common in Jews and in persons of lean body build. Among 197 patients studied with Dr. D. A. Holub, Negroes were found 1/5 as often and Jews twice as often as expected from their prevalence in the Presbyterian Hospital population. Both differences were significant at the 0.1% level. The Jewish susceptibility was much less than the 4 or 5 to 1 usually quoted and resembled that reported for leukemia, another neoplastic blood disease. No physical difference was found between polycythemic patients and normal persons from the same hospital.

Among 899 women with cancer of the breast or reproductive system, studied with G. M. Touraine and Dr. W. H. Sheldon, the White: Negro ratio was higher than expected in breast and endometrial cancer and lower in cervical cancer, at the 0.1% significance level. The well-known rarity of cervical cancer among Jewish women was confirmed. Race was unrelated to the outcome of treated breast and cervical cancer.

White and Negro women with endometrial cancer were markedly heavier, stockier, and more endomorphic than normal women and those with cervical cancer. White women with breast and cervical cancer were less gynandromorphic, i.e. more feminine physically, than normal women ($p < 0.01$). Mesomorphy was low in women with cervical cancer, both White ($p < 0.02$) and Negro ($p < 0.01$), and roughly paralleled 5-year survival in treated breast and cervical cancer.

Before speculation on these associations is warranted, they should be independently confirmed on large samples, and their mechanisms investigated along anatomical, biochemical, and genetic lines.

26. Physical anthropology in human factors engineering. Albert Damon, Howard W. Stoudt, Jr., and Ross A. McFarland, Harvard School of Public Health.

Human factors engineering deals with the design of equipment in terms of human body size and capabilities. The human factors engineer designates the appropriate tasks to the man and to the machine and designs the working environment in terms of human needs. Working together, the biologist and the engineer can greatly improve human comfort, efficiency, health, and safety, in a world increasingly man made. The pertinent biological disciplines include anatomy, anthropology, physiology and psychology.

As consultant and adviser to the engineer, the physical anthropologist can play a vital role in machine design. At the Harvard School of Public Health, for example, physical anthropologists and psychologists cooperated in a series of evaluations of commercial trucks and buses to see how well the working areas were suited to the driver. Many examples were found of inadequate space and poor arrangements of seat, controls and instruments with regard to the range of human body size and capabilities. The commercial driver population was measured directly and specific, new, design recommendations were made on the basis of these data.

The physical anthropologist also presents basic data in such a way that the engineer can directly utilize them in his designs with a minimum of difficulty and interpretation. Anthropometric data, for example, are usually presented in percentile form. An additional step, to be investigated shortly, is to determine the precise location of the points, or ranges, where space begins to affect human performance.

The ultimate goals of the physical anthropologist in human factors engineering are twofold: (1) to make it possible for all men of all sizes to operate all machines, and (2) to avoid limiting the machine's performance by human failure. Physical anthropology will have a permanent place in future human factors engineering programs.

27. The prediction of adult somatotype in the pubescent boy. Edward E. Hunt, Jr., and William H. Barton. Adolescent Unit, Children's Hospital, Boston, and Harvard University.

One of the most important longitudinal growth studies of adolescent boys was the one carried out in Oakland, California by Drs. H. R. and L. M. Stolz. These workers published a book on their findings in 1951, entitled *Somatic Development of Adolescent Boys* (Macmillan, New York).

Body build photographs of these boys were taken at intervals of about 6 months from about 11 years of age to from 16 to 18 years, in most cases. These serial photographs were made available to us through the courtesy of Professor S. S. Stevens, of the Department of Psychology, Harvard University.

On 71 boys, the photograph nearest the age of 11.5 years was selected, and the oldest photograph if the boy was followed to at least 16.5 years. Most of the older photographs were at either 17 or 18 years of age.

The senior author rank-ordered the youngest and oldest photographs according to Sheldon's endomorphy, mesomorphy and ectomorphy at both ages. These rankings were performed some weeks apart in order to reduce bias as much as possible.

The rank-order correlations between the ratings at the two ages were:

Endomorphy + 0.453
Mesomorphy + 0.501
Ectomorphy + 0.452.

These coefficients are worth comparing with correlations between dimensions of the body in the same individuals at the onset of pubescence and at maturity. Such correlations in general tend to range between + 0.70 and + 0.75. In such cases, the adolescent increment of growth tends to show a very slight negative correlation with the total measurements at pubescence, so that the adolescent growth is almost — but not quite — randomly superimposed on growth previously attained.

Differentiation of somatotype, on the other hand, is not entirely a random superimposition of adolescent events on prior developmental processes. To a considerable extent, the pre-existing body type is obliterated during adolescence, so that extreme changes of physique are not uncommon.

28. Bio-mathematics and cultural causatives. Burt W. Aginsky, Department of Anthropology, The City College, New York City.

There are at least 3 major categories of application of bio-mathematics: (1) non-domesticated animals where reproduction occurs with little or no regard to previous biological relatedness, (2) domesticated animals where man regulates or controls reproduction upon the basis of known biological ancestry, and (3) human groups where man himself imposes sanctions and taboos (culture) regarding marriage and reproduction.

Some cultural causatives which affect the quantification are: migrations, infanticide, birth control and abortion, war, travel, hazardous occupations, celibacy, restrictions as to age at marriage, endogamy, exogamy, lateral class, caste, etc., groups, lineages of first born, taboos and sanctions of marriages between related individuals, gerontocracy, wife-lending, castration, sexual abstinence re war, occupation, birth of chidren, etc.

The invariant biological factors without regard to culture are: initial and terminal ages of impregnation by males and child-bearing by females, generational count, total population effective for reproduction, ratio of males to females, and number of births per female.

Using the traditional gauge derived from ''monogamy'' and then testing the effects of cultural causatives we find that the quantity of one or more of the factors is changed and thus a different quantity results in the following: (1) the human genetic system, (2) the form of biological mating, (3) the quantity of: (a) individuals in the mating groups, (b) nuclear families, (c) individuals in the nuclear families, (d) individuals in the total population and ratio of males to females, (e) biological relationships, (f) individuals in the relationships, and (g) families in the total population.

A full presentation of this material appears in, Aginsky, Burt W., 1958: *A Solution to Kinship and Social Organization and a Theory of Human Genetic Systems.* University Microfilms, Monograph 58–1313, Ann Arbor, Michigan.

29. Stereophotogrammetry as an anthropometric tool. H. T. E. Hertzberg, C. W. Dupertuis and I. Emanuel, Aero Medical Laboratory, Western Reserve University, and Aero Medical Laboratory, Wright Air Development Center.

No abstract.

30. Variations in subcutaneous fat under isocaloric conditions. Edward I. Fry, Department of Anthropology, University of Nebraska.

No abstract.

31. Physical growth and development of Mexican and Anglo-American school children of Tucson. Richard G. Snyder, Department of Anthropology, University of Arizona.

The basic objective of this study was to determine certain aspects of the physical growth of Anglo-American and Mexican school children from ages 6 to 18, of the Tucson, Arizona, area. Both a longitudinal and cross-sectional approach was employed. Specifically considered were the physical characteristics of weight, height, annual increments, and through utilization of the Wetzel Grid technique, comparison of body-type, size, and direction of development.

The sample consisted of 416 children of both sexes, 204 Mexicans and 212 Anglos. Only those children having lived in Tuscon their entire school life were used. Basic data were obtained from each individual's school health record and the bi-annual measurements for each child's 12 year span was recorded directly onto the Wetzel Grid cards to secure the growth curves. This information was coded and transferred to IBM punch cards and electronically processed.

Intra-sample female comparison showed that the Anglo Tucson females are significantly taller at every age level from age 6 through 18 than the Mexican females, and are heavier at every age except 7. In both Tucson Anglo and Mexican females linear developmental spurts were found to precede lateral spurts by about one year. Height spurts for Mexican girls occurred at ages 10, 11, 12, while greatest weight gains occurred at age 11 and 12. Anglo girls' greatest height gains began at age 9 and extended to age 12, while their greatest weight increases occurred at age 10 to 13 years. Anglo girls began the period of greatest growth in both stature and weight one year earlier than Tucson Mexican girls, and were also found to have a larger body size at each age level. While the Mexican female is smaller, physical maturation in regard to body size is gained by age 17, while the Anglo female continues to develop slightly at least through age 18.

Tucson Anglo boys weigh more and are taller at each age from 6 to 17 than Mexican boys, being 1.6 inches taller at age 6, 2.5 inches taller at age 11, 16, 17. Mexican boys' greatest height spurt is at age 14 (3 inches), one year earlier than Anglo boys. No significant difference in physical type between these two ethnic groups was found.

Nine year old Tucson Mexican females of today are 3.9 inches taller, and Mexican boys 2.9 inches taller than those of 1925, while 12 year old Mexican girls are 3.5 inches taller and Mexican boys 1.9 inches taller today.

32. The physioprint — its applications in physical anthropology. Viken Sassouni, Graduate School of Medicine, University of Pennsylvania.

Physiography is a photographic technic which permits the taking of the facial dimensions in three planes of space with a single picture. A physiograph requires a projector, a millimetric slide, and a camera. The camera and the projector are centered on the subject at right angles to each other. The camera is situated five feet from the midsagittal plane of the subject and the projector eight feet from the transmeatal axis. A millimetric grid, with two heavy lines, one horizontal and one vertical, is projected onto the face. The head of the subject is oriented so that the horizontal line coincides with the Frankfort plane and the vertical line with the midsagittal plane. In this way, the face is accurately oriented, and the profile photograph may be taken.

I call this photograph a ''physioprint'' because, like a fingerprint, the lines of the grid delineate the pattern of the face. The millimetric grid is calibrated in such a way that the horizontal lines (not deformed) are spaced by five millimeters, and the vertical lines (deformed by facial contours) are spaced by two millimeters and they are one mm thick. This way, any dimension can be measured on the physioprint by counting the lines (heights, breadths, and depths).

This technic may be applied to cephalometry; craniometry; anthropometry; growth, genetic and racial studies.

33. A platycephalic skull from a Seneca site. A rare example of craniostenosis associated with premature closure of the squamosal and parietomastoid sutures. William S. Cornwell and Georg K. Neumann, University of Rochester School of Medicine and Dentistry, and Department of Anthropology, University of Indiana.

No abstract.

34. Cultural determinants of brain size. S. L. Washburn, Department of Anthropology, University of Chicago.

No abstract.

35. The brain as a preadaptive factor in the development of culture. Leo Estel, Department of Sociology and Anthropology, The Ohio State University.

The central idea of preadaption is the development of genetically inherited potentials making possible the utilization of new environments or a new utilization of the environment in which the new potentials develop. The major observable differential between ape and man in prehistoric times is in the utilization of the environment. Differential behavior between contemporary ape and contemporary man is mediated by differences in the size and structure of the brain. Differences in facial and postcranial morphology are relatively of small importance. The fragmentary evidence of the evolution from ape to man indicates an overlapping continuum in brain size, brain content and gross morphological skeletal structure. In the evolution from ape to man the distinguishing point between ape and man is in behavioral patterns and the utilization of the environment as indicated by tools manufactured to a continuing type. Brain size and shape for the Neanderthal type of man exhibits considerable overlapping and most, if not all, Neanderthal brain cases fall within the size and shape range of the brain cases of modern man. Burial practices among Neanderthals indicate the ability to conceptualize beyond immediate place and contemporary time. A very large discontinuity in cultural development is shown between the Mousterian and Aurignacian cultures in Europe mediated by the disappearance of the Classic type of Neanderthal and the immigration of *Homo sapiens.* The elaboration of culture exhibited by *Homo sapiens* of the Aurignacian is made possible by group organization and cooperation as opposed to the rugged individualism of the Neanderthal. The brain is a complex organ with many functions. Those areas of the human brain associated with temperamental disposition are probably the distinguishing factors between Neanderthal and *Homo sapiens* and differences in intelligence, if any, of relatively small importance. The three stages of utilization, conceptualization and elaboration were only possible after changes in the brain structure had taken place. Neither prehistoric *Homo sapiens* skeletal remains nor prehistoric cultural remains associated with these skeletons indicate biological evolutionary changes. From his inception *Homo sapiens* seems to have had the capacity for cultural elaboration making possible the new utilization of an existing environment: a brain preadapted to the development of our way of life.

36. Results of research on the skeleton of Pliopithecus (Epipliopithecus) vindobonensis. H. Zapfe, Naturhistorisches Museum, Vienna.

No abstract.

37. Middle Pleistocene human remains in Europe and northern Africa. F. Clark Howell, Department of Anthropology, University of Chicago.

No abstract.

38. The relative persistence of indigenous physical types despite repeated waves of invasion-conquest. William E. Edwards, Department of Sociology and Anthropology, University of Pittsburgh.

Recorded descriptions, paintings, statues, skeletal materials, and wide-spread linguistic stocks (''Hamito-Semitic,'' Indo-European, Ural-Altaic, Kadai-Malayo-Polynesian) indicate many cases of relative stability of physical types despite foreign invasion-conquest. Some examples may be explained by biological similarity (Roman-Iberian), conquest by minorities (Vandals, Huns, Normans), or conqueror settlement in towns and cities, with rural population replacement.

Although in most prehistoric situations ''mass migration'' was rare, there constantly occurred gradual spread, generally based on cultural and less frequently since the Upper Paleolithic secondarily on biological superiority, with fairly equivalent or, usually, greater population density of the ''conquerors.'' Explanations for physical stability under such prehistoric conditions, generally with appreciable interbreeding, include the selective removal of hybrids, all either inferior in adaption or semi-sterile, when conquerors were somewhat less numerous than the conquered; selective removal of biologically and/or culturally poorly adapted conquerors, even if more numerous, and of hybrids with a higher component of conqueror ancestry; and numerical decrease in a higher socio-economic, less fertile conqueror semi-caste. But at best the foregoing processes, even if valid, account, individually, for no more than small portions of only a minority of cases; the first process seems virtually nonexistent, while the postulated semi-caste would generally have an equivalent fertility and a lower mortality.

Detailed, quantitative analysis provides the only adequate explanation for the majority of cases. As but one illustration, assume the effective average width of the zone of fluxion (frontier area from which migrants are drawn) is 75 miles; the proportionate population increase per 25-year generation is 50%; and half those produced in excess of 50% of the population equilibrium (maximum) density level migrate, settling the previously unconquered land at 33% of equilibrium density. Then, even if the conqueror population density is regionally 3.75 times that of the conquered, and even if, in occupation of new territory, only 6% of the conquerors are killed but 75% of the conquered are killed or forced out, leaving an equivalent of only 25% of the conquered for incorporation into the dominant population through interbreeding, calculations reveal that the conquerors, spreading at the rapid rate of 1 mile per year, will be genetically absorbed with remarkable rapidity by the sparser, culturally inferior indigenous population, with 90% absorption in 258 miles and 99% in 516 miles.

The validity and wide applicability of the foregoing and related principles will be demonstrated in a series of papers on specific problems of racial and cultural history.

39. Origin of the African Pygmies. R. Ruggles Gates, Cambridge, Massachusetts.

No abstract.

40. Relationships of the African Pygmies. R. Ruggles Gates, Cambridge, Massachusetts.

No abstract.

41. The Batutsi and the Bahutu of Ruanda-Urundi. Lawrence Oschinsky, Department of Anthropology, University of Arizona.

(Read by title.)

42. Palaeodemography and disease in Bronze Age Greece. J. Lawrence Angel, Jefferson Medical College.

Almost 400 skeletons studied last summer raise the total above 2,000 (including infants). 230 excavated from 260 Middle Bronze Age graves at coastal Lerna (near Argos and Mycenae) by J. L. Caskey make a uniquely complete sample since this key phase in formation of the Greeks antedates skeletally destructive chamber tombs and later cremation. 35% are infants and 21% children, compared to 27% and about 22% in Classical Greece, 18% and 23% in Greece in 1929, and less than 5% and 4% in modern America. 15% of the 80 infants appear premature, pathological ''raying'' of skull affects 25%, and excess of males rises with age. Among adults, males average 36+ at death and females 31: an average of 3 dead children per woman plus variable signs of pregnancy stress in most female pelves suggest 6 births per family spaced each 2.5 years with selectively big contrasts in family size. Longevity improvement by Classical times of 5–10 years (much slower than now) reflects hygiene rather than medical care improvement. Statures of 166 and 154 for men and women are 3–4 cm below historic period means and 5–6 cm below Bronze Age royalty and pelves are shallow (79–80) suggesting suboptimal diet. Osteoporosis symmetrica affects 16% (thalassemia also?). Vertebral arthritis (with disk collapse) affects 75% of men and 50% of women (why in the neck region at this period particularly?), and extremity arthritis affects 41% men and 18% women. Gout and dental cyst occur alongside few traumatic deformities (ankle), wounds (15%), and fractures (under 10%). Trephination occurs.

Body build and posture, stocky and mountain-adapted, are variable. The mean Sigma Ratio is 25–30% above ''normal,'' though sacral hiatus and carabelli cusp suggest unifying gene spread. Heterogeneity is incredible. Lerna people are taller than their predecessors with bigger heads and facial breadths; their neighbors differ little, but their rulers, taller and more robust, have much bigger and more linear heads and noses and more prognathism. At Lerna short Pre-Greek types (A 18%, B 11%, D 6%, C, E, F 19%) persist alongside taller intruders (D 20%, C 13%, F 7%, E 6%). One early ''family'' group ranges from very linear beaky Iranian (D) to Mixed Alpine (E) and very short Alpine (C); a grave linkable with Vardar area pottery ranges from Alpine and Dinaroid (F) to Iranian; a man buried with a Cycladic jug is Iranian-Mediterranean. Migration thus was on an individual as well as mass basis, with differential fertility as well as tough environment as selective factors. Mixture helped to fire enough social as well as physical energy so that pressure of population growth was the key problem of the Late Bronze Age Mycenaean ''civilization.''

Proceedings of the Twenty-Eighth Annual Meeting of The American Association of Physical Anthropologists[1]

The Association met concurrently with the Central States Anthropological Society and the Society for Applied Anthropology at Madison, Wisconsin, Thursday through Saturday, May 14–16, 1959, by invitation of the Department of Anthropology, University of Wisconsin.

Five sessions were devoted to contributed papers, and one to a showing of anthropological motion pictures. One of these motion pictures is the work of a member of the Association, Burt Aginsky, and bears the title "Law in cultures and human biology." At the first scientific session President Cobb announced that $100 had been received from an anonymous donor for a prize to encourage the better delivery of papers at the annual meeting. He said also that he had appointed judges and that the judges' decision would be announced after the last session. By courtesy of the Wenner-Gren Foundation, Dr. Sol Tax, Professor of Anthropology, University of Chicago, addressed the three societies on Thursday evening in behalf of the new international journal *Current Anthropology*. The title of his address was "Anthropology around the world." Later that evening a smoker was held at a downtown restaurant, again by courtesy of the Wenner-Gren Foundation. A combined annual dinner of the three societies, held Friday evening in the Park Hotel, commemorated the centennial of physical anthropology (1859–1959). The guest speaker was the Hon. Philleo Nash, Lieutenant Governor of the State of Wisconsin and the title of his address was "On being a scientist in government." An informal smoker followed the dinner.

The Executive Committee of the Association held its regular annual meeting the evening of May 13, 1959.

BUSINESS MEETING, MAY 14, 1959

The minutes of the 27th annual meeting (1958) were approved as submitted in mimeographed form by the retiring Secretary-Treasurer, Dr. J. N. Spuhler, and as corrected by the Executive Committee.

President Cobb announced the following appointments to Committees: *Nominating Committee* (1960): Charles E. Snow, Meryl Miles, T. D. Stewart, Chairman. *Viking Fund Award Committee* (1959–1960): William W. Howells, Wilton M. Krogman, Georg K. Neumann, Charles R. Noback, Fred P. Thieme, and T. D. Stewart, Chairman. *Auditing Committee* (1959): William M. Bass, Melvin L. Moss, and Gabriel W. Lasker, Chairman. *Resolutions Committee* (1959): F. Gaynor Evans, William L. Straus, Jr., and Charles W. Goff, Chairman. Russell W. Newman was reappointed as representative of the Association to the AAAS Council for the term ending December 31, 1961.

The following new members who had been approved by the Executive Committee on May 13 were elected to membership by unanimous vote:

Virginia Carbonell
Kirby Chandler
Chester F. Chard
Orville S. Elliot
Ernest Goldschmidt
Joan Adams Haskell
Friedrich Keiter
Shiro Kondo
Morton Levine
Gregoria Loza
William Montagna
Holm W. Neumann
Wolfram Ostertag
Beverly Rettig
Raymond Seale
Joseph W. Young

The Secretary announced the death of a charter member of the Association, Dr. Rowland B. Freeman.[2]

The Treasurer gave a report on the financial status of the Association, which, owing to circumstances beyond his control (see p. 355), he had to limit to the preceding five months. This report and that of the Auditing Committee, presented by Gabriel W. Lasker, were accepted.

---

[1] Assembled from various sources in 1960 by T. D. Stewart.

[2] After the meeting it was learned that another charter member, Dr. Harry H. Shapiro, had died during this period.

REPORT OF THE TREASURER

November 1, 1958 to April 1, 1959

Bank balance on November 1, 1958 in the Harvard Trust Co.		$4000.00
Receipts: Dues received between November 10, 1958 and March 19, 1959		250.00
		$4250.00
Expenditures:		
Postage	$ 10.00	
Stationery	90.70	
Advance payment for stationery	59.70	
Payments to Wistar Institute		
Subscriptions and postage	232.17	
Excess tables and illustrations	117.39	
Train fares	40.90	550.86
Bank balance on April 1, 1959 in the Harvard Trust Co.		$3699.14

Respectfully submitted,
Edward E. Hunt, Jr., *Treasurer*
(April 2, 1959)

Statement of Auditing Committee: We have examined the records shown by the present treasurer covering transactions subsequent to November 1, 1958, and find them to be as stated. Because of the absence from the country of the previous treasurer a final audit of his books has not been possible and we recommend that this be done as soon as practicable.[3]

Signed (May 14, 1959) *by*
Gabriel Lasker
William M. Bass
Melvin L. Moss

The Managing Editor, William S. Laughlin, reported that a very satisfactory supply of manuscripts is on hand for the Journal. The printing press at The Wistar Institute is still undergoing reconstruction, and the Journal's 1959 issues may be expected in a new format starting with the appearance of the March issue late in the year.

Dr. Laughlin has agreed to edit a centennial volume of the Journal commemorating the one hundredth anniversary of the founding of the Société d'Anthropologie de Paris in 1859. The extra cost of publishing this volume is to be met by a most generous grant from the Wenner-Gren Foundation. Editorial collaborators on this project are to be William W. Howells, Gabriel W. Lasker and Mildred Trotter. It has been suggested that papers be solicited from Viking Fund Medalists and that the subject matter include material on the first century of organized physical anthropology.

President Cobb announced that the Viking Fund Award Committee for 1958–1959 had proposed the name of Henri V. Vallois, Director of the Musée de l'Homme in Paris, and that the medal had been presented at the annual dinner of the Wenner-Gren Foundation in New York on March 6, 1959.[4]

Paul T. Baker and William J. L. Felts, who had accepted the assignment at the previous meeting of reviving the PA Newsletter, admitted that they had not succeeded. After some discussion, it was agreed to let the matter drop.

T. D. Stewart gave a brief report on his visit to Czechoslovakia March 28–April 2 for the purpose of assisting the local anthropologists in celebrating the 90th anniversary of the birth of Aleš Hrdlička.

---

[3] See p. 355.

[4] See this Journal, n.s. vol. 17, no. 2, pp. 163–166.

The report of the Resolutions Committee, which was accepted, directed the Secretary to give special notice in the minutes of the meeting to the passing of a very early member and life-time supporter of the Association, Dr. Rowland G. Freeman. Also, it expressed the Association's appreciation to the University of Wisconsin and especially to William S. Laughlin and his associates in the Department of Anthropology for the opportunity to meet on their campus; to the Wenner-Gren Foundation, and particularly to Paul Fejos, the Director, for his unstinting support of things and affairs related to physical anthropology, and more especially for this year's smoker and attendant favors; to The Wistar Institute for supporting the Journal in too many ways to mention; and to the Hon. Philleo Nash, Lieutenant Governor of the State of Wisconsin, for his part in the meeting.

The Chairman of the Nominating Committee announced the following candidates for office, whose election immediately followed the closing of nominations: President, William W. Greulich, to serve until 1961; Executive Committee members: Clark Howell, to finish out Dr. Greulich's term (i.e., until 1961), and Gabriel W. Lasker, to serve until 1962; Associate Editor, Melvin L. Moss.

The meeting adjourned about 5:30 P.M.

ADDENDUM

Report of the Ex-Treasurer

April 1, 1958 to September 30, 1959

Bank balance on April 1, 1958, Ann Arbor Bank, State Street Office		$5,072.95
Receipts:		
Dues	$2,652.50	
Overpayment of dues and premium on foreign exchange	1.66	2,654.16
		$7,727.11
Expenditures:		
Secretarial expenses	$ 12.09	
Default on guarantee of 1958 annual dinner	231.30	
Payments to Wistar Institute for subscriptions and postage	2,471.40	
Editor's travel to Wistar Institute	150.00	
Printing of proceedings	219.06	
Postage	28.50	
Transferred to incoming treasurer		
July 8, 1958	100.00	
October 20, 1958	4,000.00	
Checks returned unpaid	60.00	
Bank charges	.83	7,273.19
Bank balance on September 30, 1959		$ 453.93

Respectfully submitted,
J. N. Spuhler
November 27, 1959

Audited and found to be as stated:
Gabriel Lasker
November 27, 1959

As requested by the Auditing Committee, James N. Spuhler informed me that the remaining funds of the Association, amounting to $453.93, were transferred to Edward E. Hunt, Jr., on December 3, 1959.

Signed:
Gabriel Lasker

SCIENTIFIC PAPERS

Three of the papers listed below are starred because they were judged to be the best from the standpoint of presentation. Since the Judges could not further narrow down their choice, the $100 prize announced at the beginning of the meeting was divided equally among the following: Marion Lewis, Demarest L. Polacheck, and Richard W. Young.

1. *Stature increase in the U. S. military population.* Robert M. White, Environmental Protection Research Division, U. S. Army Quartermaster Research and Engineering Command, Natick, Massachusetts.

Evidences of increases in the average stature of the U. S. military population are reviewed from data available in the literature. It may be concluded that average stature in the U. S. military population did not change appreciably between the Civil War and World War I. However, it is apparent that average stature in the military population increased some ¾ths of an inch between World War I and World War II.

2. *A preliminary report on a longitudinal growth study of college men.* Russell W. Newman, Environmental Protection Research Division, U. S. Army Quartermaster Research and Engineering Command, Natick, Massachusetts.

A two-year, longitudinal growth study was carried out by three universities, one eastern, one midwestern, and one far western, under contract with the Quartermaster Corps. Stature and other physical measurements were collected on the subjects at roughly six-month intervals. Preliminary analysis of only the stature data in relation to the chronological age of the subjects showed a pattern which differs markedly from all known age-stature series in that average stature was inversely proportional to age. In spite of this, the growth records indicate that stature increase over the two-year span was also inversely proportional to age. If the data from these three universities are accepted, some revisions of our concepts of population changes in stature during this century and prediction of growth rates seem required.

3. *Mechanics of human long bone growth; a correlated study of x-rays and biopsies.* C. W. Goff, Yale University School of Medicine, New Haven, Connecticut.

Seventy biopsies of epiphyses from 37 children and young adults, correlated with roentgenographic studies before and after operation, together with long follow-up examinations, revealed the mechanism of growth in length and breadth of the femur and tibia, under various circumstances. In many, steel markers embedded in the bony cortex, permitted accurate measurements. Two cases are presented for particular study as typical of the series. These had dissimilar screws inserted for stimulation, and staples placed across the epiphyseal disk for deceleration of growth at various times. They are informatively presented to explain increments of growth in length and breadth, deformation, tubulation and arrest.

4. *Relations of some physical properties of human bone to its microscopic structure.* F. Gaynor Evans, Department of Anatomy, Wayne State University.

The relations of tensile strength (stress) and strain and the modulus of elasticity to the number of osteons/mm^2 and their size (μ^2) were studied in transverse sections of specimens from embalmed femoral and fibular compacta of a white female 33 years of age and white males 36, 47 and 70 years of age. Sections from 18 specimens containing more than 1700 osteons were examined in ordinary and in polarized light. Although the break area of the femoral specimens was 1.5 to 2 times larger than in the fibular ones, the latter had a greater tensile stress and strain and a higher modulus of elasticity. The femoral specimens also had twice (average) as many osteons/mm^2 but they were only half (average) as large (μ^2) as the fibular osteons. There was no overlap in the range of variation in these features. The fibular specimens had fewer cementing lines/unit area and their collagen fibers were more nearly parallel to the long axis of the bone than in the femoral specimens. These facts suggest that a relatively few large osteons and fragments with few cementing lines (e.g. fibula) increase the tensile stress and strain and modulus of elasticity of compact bone. The same is true when the predominant direction of the collagen fibers approximates the long axis of the bone.

Supported by a Fulbright Research Scholarship to Italy and (in part) by Research Grant A-377(C9) from the National Institutes of Health, USPHS.

5. *The development of the sacrum in the absence of the pelvic girdle in the chick.* George R. Holcomb and Ira Fowler, Department of Anatomy, University of North Carolina.

Phylogenetic changes in the morphology of the sacrum appear to be associated with shifts in the relative position of the pelvic girdle. In vertebrates, generally, there is an apparent relationship between the size of the sacrum and the extent of its contact with the os coxae; the configuration of the lumbosacral vertebral mass in the adult fowl suggests a developmental relationship between this mass and the bones of the pelvis. This experiment represents an attempt to ascertain whether the pelvic girdle influences regional differentiation of the vertebrae of the lumbrosacral mass in the embryo.

Primordia of the os coxae and posterior limb were excised unilaterally and bilaterally in chick embryos of stages 16–17. These operated embryos were fixed at ages ranging from 15 days of incubation to hatching and were stained *in toto* with alizarin red S. A total of 67 specimens was available for study.

The configuration of the lumbosacral mass was normal in all specimens in which the pelvic girdle and posterior limb primordia were extirpated either bilaterally or unilaterally. Despite phyletic dependence of sacrum upon limb, this study demonstrates that development of lumbosacral characteristics is independent of the limb and its girdle.

Supported in part by a Senior Research Fellowship (SF-93-C) from the Public Health Service.

6. *Comparison of densities of bones of American White and Negro skeletons.* Mildred Trotter, George E. Broman and Roy R. Peterson, Department of Anatomy, Washington University, Saint Louis.

The densities of the cervical vertebrae, thoracic vertebrae, lumbar vertebrae, sacra, ribs, humeri, radii, ulnae, femora and tibiae from 80 adult skeletons (20 each of American Whites and Negroes of both sexes) were determined by relating dry, fat-free weight to volume of displaced millet seed.

The mean densities of the 10 bone series suggest 4 sub-series: (a) most dense (ulnae, radii, tibiae), (b) less dense (humeri, femora, ribs), (c) still less dense (cervical vertebrae) and (d) least dense (thoracic vertebrae, lumbar vertebrae, sacra). For males these 4 sub-series differ significantly; for females only combined sub-series, (a) and (b) vs. (c) and (d) differ significantly.

The densities of each bone series in each sex-race group decrease with age. The 10 slopes within each group do not differ significantly from each other, except in the White female where the slopes for the vertebral series and femora are less steep.

The mean densities of each bone series (except ribs) among the sex-race groups differ significantly. Sex contributes significantly in each except in thoracic and lumbar vertebrae, sacra and femora; race contributes significantly in each except tibiae.

After adjustment for age differences among the 4 groups the level of significance is altered for sacra (less significant) and femora (not significant). No important changes occur in sex contributions, but the contributions of race become less significant.

Supported by Grant A-1013 M and N, USPHS.

George E. Broman was a Summer Research Fellow, 1955–57.

* 7. *The influence of cranial contents on postnatal growth of the skull.* Richard W. Young, Columbia University.

An attempt was made to clarify the following problem: To what extent and by what mechanism does the skull adjust to changes in the soft tissues which it supports and protects? To this end, skull growth was studied by a variety of techniques in rats with normal, and experimentally decreased or increased cranial contents. This material has since been reported in detail (Young, R. W. 1959 Am. J. Anat., *105:* 383–416). Changes in cranial contents led to compensatory modifications in size, shape and spatial arrangement of functionally related tissues, including dura, bone and muscle. The cranial vault was highly influenced; the cranial base was affected to a lesser degree; the facial skull was largely unaltered. The applicability of these findings to man was verified by measurements based on frontal and lateral skull x-rays of 50 hydrocephalic and 50 microcephalic children. It was suggested that intracranial pressures resulting from expansion of cranial contents are translated into tensile forces in surrounding tissues, influencing their orientation, and stimulating their proliferation, thereby producing compensatory expansion of the cerebral capsule. (Abstract supplied in Nov. 1960.)

8. *Functional analysis of human brow ridges.* Melvin L. Moss, Department of Anatomy, Columbia University, College of Physicians and Surgeons, New York.

The frontal bone at the orbital roof in man and in the primates is responsible for the protection and support of its functionally related soft structures: the globe and the frontal lobe of the cerebrum. Ontogenetic and phylogenetic changes in the form (=size+shape) of the frontal bone, as in all other bones, are a response to primary changes in these soft structures. In the ontogenetic development of the bony orbit in both forms the globe is increasingly enclosed by the adjacent bones. In the primates there is a lack of the proportional increase in antero-posterior dimensions of the frontal lobe, as there is in man. Accordingly, the primate frontal bone produces a supra-orbital ridge in order to protect the globe. This ridge is not seen in modern man since the relative position of the anterior pole of the cerebrum directly overlies the globe. This hypothesis is supported by examination of human microcephalics with marked supra-orbital ridging.

Supported, in part, by Grant B-965, National Institutes of Health.

9. *Variability in ossification order of the bony centers of the hand and wrist.* Christabel G. Rohmann and Stanley M. Garn, Fels Research Institute, Yellow Springs, Ohio.

The order of ossification of the bony centers of the hand and wrist is customarily given as "regular" and "remarkably constant," both for the first 28 centers and for the carpals alone. Deviations from the usual sequence are said to be associated with late ossification and more common in children in poor health.

While mean ossification orders as given in the literature are in fair agreement, mean and median orders from the *same* study differ to an equal extent. Individual ossification sequences, moreover, may deviate greatly from the mean and median orders with rank deviations (Σd) as high as 100 for a given child. Individual centers may exhibit rank deviations as great as 18 out of a possible 28. Out of 154 boys and girls only 49% of the boys and 61% of the girls adhered to the Capitate-Hamate-Triquetral-Lunate-Greater Multangular-Lesser Multangular order commonly given. Fifteen of the mathematically possible 36 carpal sequences actually occurred.

Actually, the degree of pattern variability was not significantly correlated with mean ossification age ($\bar{X}T$). Children most deviant in ossification order did not experience more acute illnesses during their first 7 years. There was clear evidence that the most extreme pattern deviations tended to be repeated in the subsequent generation.

From the present study it is unlikely that any bony center of the hand and wrist holds an unvariable rank in the ossification sequence, and the inutility of massed data ossification orders is clearly seen.

10. *A preliminary report on the skeletal material from Little Salt Springs, Florida.* Louanna Pettay, Indiana University.

This paper is a preliminary report on the skeletal remains recovered from Little Salt Springs in the central Gulf Coast region of Florida. The presence of human remains from such a site raises a number of interesting problems and while many of these problems cannot be solved from information obtained from skeletal remains alone this material may serve to delimit some areas of the problems. With this in mind, the quantity and type of bone, age and sex distribution, physical type, and other characteristics of the skeletal material are discussed and some inferences drawn. Some of the conclusions which are tentatively advanced on the basis of this material are:

1. The human remains were intentionally deposited in the Spring.
2. The skeletal remains represent secondary burials.
3. The Spring was used for burial purposes by a relatively late Indian group conforming, in general, to a physical type found elsewhere in the Southeast.

11. *The relationship of human size to strength.* William E. Edwards, University of Pittsburgh.

Homo sapiens offers marked advantages over all other species available for strength testing, for a greater variety of complex tests for various groups of voluntary muscles can be performed more rapidly with simpler instruments, while motivation can be made unusually uniform. Strength test scores should have a fairly normal distribution within each small body-weight interval, and the means or any other equivalent points might expectably conform quite closely to the proper exponential curve. But the many variable determinants, such as age, sex, genetically determined potentialities, nutrition, exercise, disease, and motivation, require an almost infinitely large total sample and would in any case distort the resultant curve.

Since there is surely a physico-chemically determined upper limiting asymptote for muscle strength per unit of cross-sectional area, if it were possible to identify the uppermost percentile strength-score subjects in each body-weight interval, their scores should conform very closely to the expectable curve. Practiced weight-lifters, especially regional and world champions, provide such a sample, with good selection for all the more significant variables cited.

A scatter diagram of weight-lifting scores of a small, random sample from the general population manifests virtually no consistency of trend. But scores for novice lifters cluster about the curve, while those of regional champions conform more closely. World record lifts conform to the expectable curve almost precisely, with the exception of the heavyweight class, in which the addition of fatty tissues provides no marked disadvantage. Even the minute deviations from the expectable curve, slightly lower for the lightest and for the heaviest weight classes, were anticipated, for both the lightest and heaviest lifters are selected from a smaller total population of proportionately unusually strong subjects, while the lightest probably also have higher skeletal and the heaviest higher fatty components.

The graphically evident differences in degree of conformity with the expectable curve between press, snatch, and clean-and-jerk scores can be explained by the progressive increase in the significance of factors other than strength.

12. *A technique for discovering the major dimensions of an organism.* C. Loring Brace, Harvard University.

An adequate consideration of all the major dimensions of an animal—human or non-human—requires the examination of a large number of measurements and their inter-relations. The number of coefficients of correlation between all of the measurements necessary to describe an aspect of an organism even crudely is so great that interpretation becomes difficult. When the measurements necessary to describe several aspects are all considered at once, adequate interpretation of the resulting number of coefficients of correlation is effectively impossible. Factor analysis and the use of high speed electronic computers can bring such an approach within the realm of possibility. This paper reports on a study where use is being made of the technique described.

13. *Fat accumulation and growth status in childhood.* Stanley M. Garn and Joan A. Haskell, Fels Research Institute, Yellow Springs, Ohio.

As part of continuing studies of the biological implications of fatness at various developmental levels, the thickness of the lower-thoracic fat shadow was compared with length and bone age in children and adolescents. Fat and length were positively correlated from 1.5 years on, reaching a maximum in preadolescence, then dropping below the 5% confidence level. Fat and bone age (Greulich and Pyle) were significantly correlated in both sexes at 8.5–9.5 years (girls, 0.41; boys, 0.35) and at 12.5–13.5 years (girls, 0.45; boys, 0.26). The use of partial correlations to correct for secular trends did not appreciably alter the results. It was concluded that greater fatness was linearly associated with increased size and accelerated maturation from infancy through adolescence. In extreme cases, the fat-related developmental acceleration was equivalent to two years of normal growth.

14. *Subcutaneous tissue in adolescent females.* Edward I. Fry, Department of Anthropology, University of Nebraska.

There are few prior studies on the amount and distribution of subcutaneous tissue in adolescent females. A specially designed gown enabled this elusive group of subjects to be studied.

The Harpenden caliper was used to measure subcutaneous tissue on the abdomen, back, upper arm and lower arm of 257 females 18 to 21 years of age. The statistics calculated include measurements of central tendency and the 5th, 25th, 75th and 95th percentiles. Correlation coefficients of some of these dimensions were also calculated.

The relationship between the Harpenden caliper measurements of subcutaneous tissue and those from dissection are discussed.

15. *Extraction and concentration of ABO(H) substances from human bone.* Margery P. Gray, Department of Anthropology, University of Wisconsin.

ABO(H) types of human bone established by absorption of anti-A and anti-B with ground bone are subject to considerable skepticism. Inhibition of agglutination may result from an antigen-antibody combination but it also may result from chemical denaturation due to soil minerals, bacterial contamination or adsorption of proteins to the bone particles. The presence of water insoluble forms of blood group polysaccharides in the organs and tissues of non-secretors and secretors alike has been well established. The present paper describes a method for isolating a fraction from human bone containing blood group activity free of interfering substances.

A bone sample (15 to 20 grams) is thoroughly washed in distilled water and decalcified with either 10% versene or EDTA. While the weight of sample needed is considerable, it is not necessary to sacrifice bones needed for measurement. Rib or scapula fragments are just as satisfactory as vertebrae or long bones. It is not necessary to separate cancellous from cortical tissue. The decalcified bone is mashed, washed and digested with pepsin. The resulting digest is first cleared by filtration, then dialyzed against distilled water, and finally fractionated by gradual addition of acetone. Precipitates obtained by addition of not more than 2.5 volumes of acetone contain any blood group activity. The dried fractions are dissolved in saline and tested for inhibitory activity against anti-A and B.

Three lots of immune anti-A and two lots of immune anti-B have been produced in chickens by inoculation with active fractions obtained from human bone.

Supported by National Science Foundation (G3923) and the Wisconsin Alumni Research Foundation.

16. *Stability of bone collagen: I, Fossil proteins.* Todd M. Schuster, James N. Spuhler, University of Michigan, and Fred P. Thieme, University of Washington.

Fossil bones of various ages were subjected to chemical analysis to ascertain the stability of the constituent protein. Certain peptides appear to be regularly present indicating a non-random polymeric decomposition. The reaction kinetics of this process are discussed in terms of the primary, secondary, and tertiary structures of protein. The use of this and related amino acid compositional data is discussed with an eye toward possible age determinations and phylogenetic studies.

17. *Mating types in the ABO blood system: Their association with fertility level.* Jack Kelso, University of Colorado.

This paper presents the results of analyses designed to test the association between fertility level and certain classes of ABO mating types. The results are based on 158 married pairs selected at random from the resident adult population of Ann Arbor, Michigan. These subjects were selected as participants in the Assortive Mating Study.

The first problem to be approached may be stated in the form of a question: Are spouses who are phenotypically the same for the ABO characteristic associated with a higher or lower fertility level than might be expected on the basis of chance? The results of a chi-square test indicated that there was a significantly large association, and that the homogamous pairs were substantially less fertile than the heterogamous pairs.

Since certain types of heterogamous matings are suspected to be heterospecific, that is, affected by maternal-fetal serological incompatibilities, a further question arose: Among the heterogamous pairs, are there significant differences between heterospecific and homospecific matings? In the testing of this hypothesis, no siginficant association between fertility level and the two types of heterogamous matings was obtained.

One further procedure was applied to the data: The determination of average fertility for each of the three mating types (homogamous, homospecific and heterogamous heterospecific). Ranking these averages indicates that the homogamous marriages are the least fertile, the heterogamous heterospecific intermediate, and the heterogamous homospecific showed the highest average fertility.

These results are consistent with the proposition that the heterozygote enjoys some selective advantage, since the heterogamous matings can be expected to produce a higher proportion of heterozygous offspring than the homogamous matings.

18. *The bloodgroups, abnormal hemoglobins, and hemoglobin values of pregnant women in Liberia.* Frank B. Livingstone, Department of Human Genetics, University of Michigan.

Data are presented on the blood groups, abnormal hemoglobins, and hemoglobin values of pregnant women attending the antenatal clinic of the Lutheran Mission Hospital, Zorzor, Liberia. The frequencies of the ABO and MN blood group genes among the pregnant women of the Kpelle and Loma tribes, who constitute the great majority of the sample, are not significantly different from a control sample of these tribes. There is, however, among the pregnant women a decrease in the number of MN heterozygotes, which is significantly different at the 1% level from the number expected in a Hardy-Weinberg equilibrium. The frequency of Rh–(dd) phenotypes among the Kpelle and Loma pregnant women was 18%, while it was 3% among the control sample, a difference which is significant at the 0.1% level. Two explanations for the increase in Rh– phenotypes among the pregnant women are offered.

19. *Ripples in a gene-pool: the shifting frequencies of blood-type alleles among the Hupa Indians.* Frederick S. Hulse, University of Arizona.

The distribution of allelic frequencies at the ABO, RH, MN and Duffy loci among the inhabitants of the Hupa Reservation in California are presented and examined. Differences between the several tribal groups and between the different generations are analyzed. A reconstruction of aboriginal gene-frequencies for the Hupa, Yurok, and Karok tribes is attempted, and gene-frequency comparisons made to the gene-frequencies of other Indian tribes of western North America. It is noted that shifts in gene-frequency at the ABO and RH loci are taking place, for the most part because of the arrival of newcomers to the Reservation. An attempt is made to elucidate the sources and the course of admixture through the years, not only by this analysis but also by presentation of certain family lines. The way in which assortive mating has delayed the attainment of genetic balance is illustrated, but it also is shown that a restabilized gene-pool is coming into existence.

20. *Blood group gene distribution in Eskimos: A possible blood group selective factor.* B. Chown, M. Lewis, H. Kaita and J. Hildes, University of Manitoba, Winnipeg.

An analysis of published and unpublished blood group gene frequencies suggests, on the basis of the genes B, R_2, N, Ns, that the Eskimo population centering around Hudson Bay may differ genetically from Eskimo elsewhere and may possibly represent a residuum of the Dorset people. On the other hand, a new observation suggests that the gene *r* (cde) may have selective value against pulmonary tuberculosis or chronic pulmonary disease. If such selection exists, it may invalidate some anthropologic conclusions based on blood group gene frequencies.

* 21. *The blood groups of the Kutchin Indians at Old Crow, Yukon Territory.* M. Lewis, J. Hildes, H. Kaita and B. Chown, University of Manitoba, Winnipeg.

A study of the blood groups of the 114 Kutchin Indians living at Old Crow, Yukon Territory was made in the fall of 1958. At the same time a detailed genealogy through 5 generations was drawn up, and cousin matings were found to be not uncommon. The gene frequencies for the 92 apparent pure-bloods were as follows: ABO system, O 1.0000; MNSs system, MS 0.1895, Ms 0.5931, NS 0.0876, Ns 0.1298; P system, P_1 0.1595 P_2±p 0.8405; Rh system, CDe±Cde 0.2066 cDE±cdE 0.7554, cde±cDe 0.0326, CDE±CdE 0.0054; Kell system, k^b 1.0000. Other blood groupings carried out were: Duffy system Fy(a+) 1.0000; Diego system, Di(a–) 1.0000 Yt(a+) 1.0000; Lewis system Le(a+) 0.0543 Le(a–) 0.9457; Mi(a–), Mg– and V–, 1.0000 The addition of White genes as detected in the remaining 22 individuals introduces B, and increases the frequencies for N, S, P_1, CDe±Cde and cde±cDe, and increases the ratio of Le(a+) to Le(a–).

22. *Blood groups of Alaskan Eskimos and Indians.* F. H. Allen, Jr. (Boston), P. A. Corcoran (Boston), A. C. Allison (London) and B. S. Blumberg (Washington).

During the course of field work in Alaska in the summer of 1958 (Blumberg and Allison) blood specimens were collected from Eskimos and Indians for blood grouping and other investigations. The samples were flown to Boston, where the blood typings were performed (Corcoran and Allen). Two hundred and forty-one Eskimo bloods and 285 Indian bloods were tested. Reagents used were antibodies against blood factors A, A_1 B, H, C, C^w, c, D, E, E^w, e, f, G, rh_1, M, N, S, M^g Mi^a, Vw, K, k, Kp^a, Kp^b, Fy^a, Jk^a, P, Le^a, Le^b Lu^a, Di^a, Wr^a, Be^a, Vel, and Js.

The most interesting finding was the near absence of factor Di^a amongst the Indians, only 1 of the 285 being Di(a+). Among the 241 Eskimos, 2 were Di(a+), the first Di(a+) Eskimos so far encountered. (Chown and Lewis have tested large numbers of Eskimos without finding any Di(a+).) In previous Indian populations tested, the frequency of Di(a+) has always been relatively high: about 10% in Crees and Chippewas (Lewis, Chown et al.), 6% in Penobscots (Allen et al.), up to 35% in South American Indians (Layrisse et al.). Di(a+) has been found in only 1 European, he being the husband of a woman who was discovered to be sensitized to Di^a through pregnancy. Colburne et al. have suggested that the frequency of Di^a may be related to the time of its dispersal from some center of Mongoloid evolution. There is also the possibility that the gene is related to cold adaptation.

23. *Anti-H specificities of blood in the newborn.* Charlotte M. Otten, University of Minnesota.

Several anti-H phytagglutinins (lectins) were investigated in their reactions to newborn blood group O cells. It was found that these agglutinins fell sharply into two classes: those which agglutinated infant O erythrocytes to a level of reactivity comparable to that exhibited by adult O cells, and those which agglutinated infant cells very weakly or not at all. The adult serological pattern was attained, in the latter case, at six to ten months of age.

It was found that the former group of reagents (*Laburnum alpinum, Laburnum anagyroides, Ulex europaeus, Cytisus sessilifolius*) were inhibited by salicin (according to Krupe), but not by l-fucose. L-fucose and closely related sugars, on the other hand, inhibited those agglutinins which had little effect on cord O cells (*Lotus tetragonolobatus*). Watkins and Morgan ('52) had noted this in regard to eel anti-H, which has a specificity closely approximating that of *Lotus*.

Several specificities of anti-H had been postulated before by the above authors, of which commonly-utilized plant agglutinins apparently represent two classes. It is suggested, therefore, that representatives of both classes be used in agglutination and inhibition studies. Inconsistencies appeared in using two such reagents in studies on saliva and meconium inhibition. (Abstract supplied in December, 1960.)

24. *Key areas and key species in problems of distribution of African monkeys.* N. C. Tappen, Department of Anatomy, Emory University.

A recently completed study of the distribution and adaptation of the African monkeys reveals many striking irregularities of locality. In some cases these are readily related to the kind of habitat favored by the animals; many others do not suggest simple causes. There are problems of presence or absence of species in restricted localities and in great geographical regions. The solutions of some of the problems should contribute to the climatic and geological history of the continent. Distributional peculiarities may be significant in understanding the differentiation of African monkeys and the evolution of the primate order. A few of the key species are discussed in order to bring some idea of the range of the problems: *Erythrocebus patas, Cercopithecus aethiops, Papio doguera, Cercopithecus mitis, Cercopithecus l'hoesti, Cercopithecus preussi, Cercopithecus diana, Cercopithecus dryas, Cercocebus galeritus,* and *Cercocebus albigena.* Alternative hypotheses of the relative times and places of origin of some of these species are offered. They are related to information about the broad classification of vegetational zones where different species are found, but much more detailed studies of monkey ecology are needed. Some territories where such studies may be particularly valuable are indicated.

25. *Observations on the opposability of the primate thumb.* Warren G. Kinzey, Department of Anthropology, University of Chicago.

The opposability of the thumb has long been considered a primate characteristic, although the differences in this ability among the living primates have not been systematically studied. In order to study the behavioral differences in pollex opposition representatives of 18 genera of primates (including nearly all families) were observed and cinematographed in standardized grasping situations. Particular attention was given to the manner of opposition of the thumb.

The following general tendencies are noted among the primate groups. The "power grip" (Napier, '56) is found among all primates studied, although in some (e.g., *Pithecia, Cacajao*) there is no counter-pressure applied by the thumb. The "precision grip" utilizing the flexor aspects of the fingers and the opposing thumb, easily seen in the grasping of a small object (e.g., a sunflower seed) is most commonly seen in the arboreal *Cercopithecus* monkeys. This is generally modified by the more ground dwelling macaques and baboons so that the thumb is "opposed" to the *radial side* of the fore-finger. Although this difference is apparent in these standardized situations, the latter animals may often be seen to utilize a fine precision grip with an "opposed" thumb when grooming.

Among the apes the "opposed" thumb is rarely observed in the gibbon or the orang and much less frequently than might be expected in the chimpanzee and the gorilla. Since the degree of rotation between the transverse axes of the thumb and forefinger is greater on the average in the apes than in man, the grasping behavior of the anthropoid apes appears to reflect habitual use of their hands in movements (such as brachiation) in which the thumb is not opposed.

Supported by a grant from the Ford Foundation to Dr. S. L. Washburn for the study of the evolution of human behavior.

The author gratefully acknowledges the use of facilities at Chicago Zoological Park, Brookfield, Illinois, and Lincoln Park Zoo, Chicago, Illinois.

26. *Human gait, hip joint, and evolution.* J. Lawrence Angel, The Daniel Baugh Institute of Anatomy of the Jefferson Medical College.

Neanderthal man, prehistoric Greeks, other hill peoples show ankle facets, tibial retroversion, femoral antetorsion with wider joint motion plus flatter shafts and bone markings from stronger glutei and quadriceps muscles compared with modern urbanites. The human hip joint, usually overlooked, has tremendous ilio-femoral ligament and zona orbicularis which tightly screw the femoral head into its socket before 15 degrees of extension past vertical. Rapid descent of steep slopes throws the driving femur into extension with a little abduction and external rotation and hence stresses the antero-superior area of femoral neck. Sharpness of zona links significantly with degree of crescentic plaque (Poirier's empreinte) developed here. But 30% to 50% of prehistoric Greek females and children (and 10% of males) show an inflammatory erosion fossa (Allen's fossa) penetrating cortex, an extreme reaction to downhill bent-knee gait starting before complete ossification. Fossae or plaques correlate poorly with other items: great individual flexibility in gait.

Evolution of human bipedal gait produced backward bending in ilium and in lumbar areas (Weidenreich et al.) cephalad from the hip because ligament design (plus muscle placement around acetabulum) limited extension backward of the femur. Ligament tightness in extension (plus knee collateral ligaments behind line of weight-bearing) allows a muscle-less standing at ease posture. Ligament tightness in gait tends to promote pelvic tilt, lordosis, and femoral neck fracture in aging individuals.

Supported by N.I.H. Grant A-224 and continuations (and by Guggenheim, Wenner-Gren, and American Philosophical Society fellowships).

27. *Race, society and nonsense: The American White as a race.* L. Estel, Ohio State University, Columbus. (Read by title.)

28. *An index of the breeding isolation of communities: Peru.* Gabriel W. Lasker, Department of Anatomy, Wayne State University, Detroit.

In a census of persons born in a community, the listings of birthplaces of parents permit the calculation of an immigration rate in the genetic sense for the previous generation. Such a parental immigration rate automatically weights the individuals for differences in fertility; parents of more than one surviving child in the community will be recounted for each additional child.

Sample censuses of 5 towns in a strip of the North Peruvian coastal plain yield parental immigration rates of 13 to 29%. This may be compared with recent immigration (16 to 45%), with data from birth registries of various dates during the last 50 years (10–51%) and for different types of community such as open country, *campiña,* and plantation, *hacienda* (22–78%).

The index of breeding isolation, the product of the immigration rate multiplied by the size of the effective breeding population, would not be as low as 50 anywhere in the whole zone under study. On theoretical grounds one can postulate that an index of isolation below 50 would be required for appreciable local differentiation by random or natural selection. For the last two generations, however, even the peasant communities studied in every instance manifest breeding patterns which favor racial amalgamation.

29. *The Batutsi, the Bahutu and the Batwa of Ruanda Urundi.* Lawrence Oschinsky, National Museum of Canada.

The Batutsi, the Bahutu and the Batwa inhabit the mandated territory of Ruanda Urundi on the eastern border of the Congo Republic. They are in a sense socio-economic castes of a tribe which might be referred to as the Banyaruanda. The Batutsi are cattle owning aristocrats, the Bahutu, agricultural serfs and the Batwa are hunters. Morphologically the groups are quite distinct. The Batutsi are tall, narrow nosed, narrow faced Negroids showing evidence of previous Caucasoid admixture, the Bahutu are intermediate in stature and have broader noses and faces, and the Batwa represent a local variant of Congo pygmy racial type. In the ABO, Rh and MN blood group distributions the Batutsi and the Bahutu are similar. In sickle cell distribution the Batutsi and Batwa have low percentages while the Bahutu of Ruanda have 5.2% and the Bahutu of Urundi have 11.8%.

The morphometric data of the 3 groups show clear and distinct differences between them. The blood group data show little difference between them, whereas the sickle cell data lump the tall hamitomorphic Batutsi with the pygmy Batwa. It is apparent that monogenetic serological factors because of genetic drift, mutation, selection, and hybridization have limited value in racial taxonomic analysis. (Abstract supplied in Nov. 1960.)

30. *Race, language and culture in aboriginal North America.* G. K. Neumann, Indiana University.

(No abstract.)

31. *Body weight, climate, and nutrition in New World aborigines.* Marshall T. Newman, Department of Anthropology, University of Michigan.

The correlation between mean coldest month temperature of locality and mean body weight in 55 adult male native American series is highly significant at -0.717. Since mean stature shows a similar temperature correlation of -0.537 and is also strongly related to weight at $+0.819$, the regression of weight per unit stature on temperature is: $\text{Weight} = -0.8633\,(\text{stature}) - 0.0839\,(\text{temperature}) - 75.99$. The standard deviation is 2.93 kg. For a given series, weight thus calculated affords a practical measure of actual weight excess or deficiency on an average basis.

In the series used here, the greatest differences between calculated and observed weights are 1.4 to 2.4 times the standard deviation, suggesting that factors other than the body mass-temperature relationship are strongly operative. Of these in 10 series, the Copper-W. Hudson Bay, S. W. Greenland, and Aleut (average at a mean of 40.8 years) are the heaviest Eskimo for their statures and ambient temperatures; with those from St. Lawrence Island and the Alaskan Arctic Slope the lightest. For 44 Indian series the heaviest viewed this way are the dietarily acculturated Arizona Papago and Chilean Mapuche, and the Tucano of the Upper Rio Negro, while the lightest are the Navaho and Zuni. Contrary to their reputedly indifferent nutritional status, most Mexican and Middle American Indians are not significantly deficient in weight for their low statures. In fact, all 7 lowland Maya series are somewhat heavy, and only the very poorly nourished Trique of Oaxaca and the Huastec and one Nahua (Chiconamel) series from Vera Cruz show weight deficiencies over one S.D.

Of the factors making for significant weight excesses or deficiencies, the most important is probably nutritional status. But in most cases special studies are needed to differentiate the direct influence of diet from other determinants such as health and disease, workload, age, and genetic body build.

32. *Racial taxonomy and cold adaptation.* Paul T. Baker, Department of Sociology and Anthropology, The Pennsylvania State University.

Racial classificatory systems of man are presently based on a combination of anatomical and serological characteristics. Although these systems strive to determine the genetic distances between groups of men by use of a number of known and assumed genes, they fail to implement the extant knowledge from a third parameter of human characteristics: function. Genetically directed function or specifically physiological mechanisms are highly susceptible to post-conception environmental modification. This fact probably led recent physical anthropologists to neglect this important area, but modern work shows the inheritance of function to be at least as clear as the inheritance of anatomical structure. Furthermore, a knowledge of function provides the necessary link between the biology and culture of man.

In this paper, the mechanisms of physiological cold adaptation are discussed in relation to the environment of the group and how such mechanisms could serve in racial classification. The evidence now suggests that there may be at least three different mechanisms which serve to enhance performance, depending on the nature of the cold environment. The first, an extreme reduction in peripheral blood flow during sleep, permits the maintenance of essential core temperature without a large increase in metabolism. Thus, individuals may sleep nude in cold temperatures above freezing. Second, the deposition of heavy subcutaneous fat layers which permit the individual to survive nude in temperatures which are continuously cold but above freezing. Third, an alternating vasoconstriction-vasodilation of blood vessels in the extremities when the limb is exposed to cold. This mechanism may reduce frostbite incidence when clothed individuals operate in an environment below freezing. These mechanisms vary appropriately in their presence and intensity among groups of men from different climatic and cultural backgrounds, and seem only partially susceptible to the effect of the lifetime environment.

33. *Neanderthal footprints and possible evidence for magic in Basua cave (Savona, Italy).* A. C. Blanc, University of Rome.

(No abstract.)

34. *The form of the pubic bone in Shanidar I and Shanidar III.* T. D. Stewart, Division of Physical Anthropology, U. S. National Museum, Washington, D. C.

In describing the pelves of the Mount Carmel remains McCown and Keith ('39) stated ". . . in the total assemblage of characters we meet with a larger proportion of Neanderthal features than are met with in any modern race of Neanthropic man. That is true of all the specimens from the Skhūl cave, but the woman (Tabūn I) from the Tabūn cave presents an altogether peculiar pelvic picture. Her pelvis differs not only from those of the Skūhl people but presents features, particularly in the conformation of her pubic bones, which have not been met before, either in living or in fossil man . . . We cannot think that her pelvic features are merely a manifestation of individual variation; they seem too sharply defined for that. The pelvic features force upon us a need for hesitation in regarding this remarkable woman from the Tabūn cave as a mere variant of the Skhūl type" (pp. 71–72). In view of this statement the Shanidar pubic bones are of great interest. Pubic bones do not exist for any other Neanderthals.

The features in question consist of a thinning and lengthening of the superior ramus of the pubis and of a resultant great enlargement of the obturator foramen. Exactly the same thing occurs in Shanidar I, presumably a male. Also, a fragment of the superior ramus from Shanidar III (male?) shows the same peculiar thinning. By contrast the pubic bones of the Skhūl specimens (IV and IX) are very different and essentially modern. These facts taken together with the contrast in skull forms (Skhūl: progressive; Tabūn-Shanidar: conservative), suggest that Skhūl is not a hybrid between a hypothetical *Homo sapiens* and a Neanderthal but rather an actual forerunner of modern man; and that Tabūn-Shanidar is a true Neanderthal—a side line in human evolution.

35. *Indirect evidence of the primitiveness of the Swanscombe skull.* T. D. Stewart, Division of Physical Anthropology, U. S. National Museum, Washington, D. C.

The fact that Le Gros Clark and Morant in their original descriptions ('38) of the Swanscombe occipital and parietal bones were unable to find clear distinctions with *Homo sapiens* provided a basis for the view that the modern skull form has a great antiquity. Although few physical anthropologists now believe that Swanscombe is an "ancient modern," the recent change in viewpoint is due to considerations other than morphological.

It would appear that no one has noted the presence in Swanscombe of the occipital portion of a prominent masto-occipital ridge. The masto-occipital suture occupies the crest of this ridge. Such a feature is characteristic of Neanderthals, being associated in that group with a large digastric fossa and a diminutive mastoid process. This point will be illustrated by a drawing of the Swanscombe occipital bone oriented with the foramen magnum horizontal and by similar drawings of Shanidar I, La Ferrassie and *Homo sapiens.* This is convincing evidence that Swanscombe had a mastoid structure similar to the Neanderthals. If it was indeed the case, then the supraorbital ridges of Swanscombe could hardly have been of the modern form, as Montagu argued from the fit of the Wallbrook frontal, because reduced supraorbital ridges usually go with enlarged mastoids and reduced masto-occipital ridges. Thus, to paraphrase Morant, " . . . the missing parts of the Swanscombe skull *probably were* so formed as to provide clear evidence of differentiation from modern man."

36. *On phylogenetic aspects of the human brain.* C. R. Noback, Department of Anatomy, Columbia University, College of Physicians and Surgeons, New York.

(Read by title.)

37. *The dentition of the Magdalenean female from Cap Blanc, France.* A. A. Dahlberg and V. Carbonell, University of Chicago.

The dentition of the young female skeleton of the Upper Paleolithic from Cap Blanc, Dordogne, France, which is in the collection of the Chicago Natural History Museum, stands out in sharp contrast to other forms, notably the Mongoloid and the Neanderthaloid. This supports the contention of later workers that the Magdalenean peoples were not related to the Eskimo as had one time been suggested. The dentition shows evidence of particular trends towards reduction in size and form of the teeth and in some of their parts. The left lower third molar is missing, congenitally, the teeth are small, the hypocones of the upper molars are reduced, there are no protostylids or Carabelli's cusps, and the tooth surfaces are smooth with no evidence of wrinkling, even in their early phases following eruption. There is no evidence of shovel-shaping, the pulp chambers and roots are small, hyposodont. The advanced patterns of the lower molar occlusal surfaces of Y5, +4, +4 range from the first to the third molars. The teeth are worn less than might be expected for a person of this age in this environment. (Abstract supplied in Nov., '60).

38. *A preliminary genetic analysis of shape in the human anterior dentition.* Renée M. Menegaz-Bock, Department of Anatomy, University of North Carolina and A. A. Dahlberg, Zoller Memorial Dental Clinic and the Department of Anthropology, University of Chicago.

The purpose of this study is to objectify and to quantify certain traits of the anterior dentition of Pima Indian which appear to show familial similarities. A suggestive intial study based on measured depth of shovel-shaping showed highly significant between-family variation relative to within-family variation, even when general size was controlled by analysis of covariance ($F_{2,35} = 9.33$).

The following 11 incisor traits are also useful in the description of familial characteristics:

1. Anterior mesio-distal curvature,
2. Posterior mesio-distal curvature,
3. Anterior apico-incisal curvature,
4. Posterior apico-incisal curvature,
5. Lingual ridge height in the bucco-lingual direction,
6. Lingual ridge placement (incisally, gingivally, full length; parallel, converging, diverging),
7. Buccal edge shape and placement,
8. Buccal lateral ridges,
9. Cingulum characteristics,
10. Mesio-distal length,
11. Bucco-lingual width at the level of the measured section, i.e., at the point of the deepest part of the ridge and fossa formation.

Traits 1, 2, 5, 7, 8, 10 and 11 are measured on enlarged photographs of horizontal cross-sections of casts of the incisors; traits 3, 4, 6 and 9 are categorized from observations on whole casts.

Correlation analysis on 5 measures taken on the horizontal cross-sections shows the traits to be relatively uncorrelated, and the intra-familial correlation to be rather high. In particular, lingual ridge height and posterior curvature appear to be independent. This complexity of the shovel shape trait may account for part of the difficulty in working out a mechanism of inheritance.

An example of the heuristic value of gross observations is the occurrence in one family of a high degree of anterior mesio-distal and apico-incisal curvature in the grandmother which is reflected in all her daughters and very little in her sons. In the same family, a woman marrying in apparently is the dominant influence in the lesser anterior curvature and deeper shovel shaping of the incisors of her children when they are compared to the incisors of their father.

Supported in part by USPHS Grant No. D165.

39. *Mesial-labial ridging in incisor teeth.* Richard G. Snyder, University of Arizona.

A previously undescribed morphological character is reported upon which has been observed on the labial surface of incisor teeth. In line with the taxonomic nomenclature of Hrdlička ('20) of "shovel-shape," and Dahlberg ('47) of "double shovel-shape," such teeth could be described as "three-quarter double shovel-shape." This trait was observed to be present in a large population of prehistoric Arizona Indians. Incidence of this character in various groups may be of value in comparative odontological population studies.

* 40. *Interrelationships in tooth formation.* Demarest L. Polacheck, Stanley M. Garn and Arthur B. Lewis, Fels Research Institute, Yellow Springs, Ohio.

This study is concerned with the extent to which the mandibular molar and premolar teeth are consistent in developmental status during growth, and the extent to which they reflect variations in sexual and somatic development.

Tooth calcification stages (beginning calcification, crown-completion/root-formation, and apical closure) were moderately correlated, with a mean combined-sex r of 0.47 for 19 stages of 5 teeth. Correlations between calcification stages and size, weight and bone age were low, averaging 0.15 for 8 combined-sex correlations.

Tooth eruption stages (alveolar eruption, attainment of the occlusal level) were positively correlated, with a mean r (computed from z-transforms) of 0.56 for 8 stages of 4 teeth. Correlations between tooth eruption stages and sexual maturation (menarche) were of a moderate order, averaging 0.43.

In summation, calcification of the teeth within the jaws, and movement of the teeth through the jaws and gums appear to be separate, partially autonomous phenomena.

Supported in part by United States Public Health Service Grant M-1260.

41. *Bioassay and growth: A developmental analysis of the mandibular central incisors.* E. A. Fanning and E. E. Hunt, Jr., Forsyth Dental Infirmary for Children, Boston.

An "attainment curve" represents the percentages of children at a given range of ages who are *at or beyond* a stage of somatic development. Where percentages are expressed as probits and ages as the logarithms of age from conception, attainment curves are often linear. Within a tissue, lines for successions of stages are then parallel, if the stages are completely irreversible. The slope of such a line of parallel succession is the standard deviation of the time of attainment in units of log conceptional age.

This mathematical model is formally similar to a bioassay where probits depict the percentages of responding organisms to a drug or other stimulus whose dosages are plotted on a log scale. The logarithmic increase of dosage is thereby multiplicative, or increasing at a constant percentage rate per unit of length of the log axis. By analogy, perhaps trophic stimuli or hormones in children also increase multiplicatively, so that attainment curves are true dosage responses, and tissue growth is then "nature's bioassay."

In a longitudinal study of incisor development in 100–220 Boston children, three systems of parallel attainment lines were found. Within each system, boys and girls were parallel. One pattern was the line describing the clinical emergence of the deciduous mandibular central incisor. Its standard deviation was intermediate. Most variable was the system characterizing the subsequent stages of root resorption of this tooth. Least variable was a system for the exfoliation of this tooth and for all developmental stages of its permanent successor (calcification of crown and root, emergence from the alveolus, and clinical emergence).

These findings seem to indicate three multiplicatively increasing trophic stimuli in a population of growing children. One, with a moderate rate of multiplicative increase, presumably triggers the onset of calcification of the deciduous mandibular central incisor, and if deciduous calcification and emergence show the same parallelism as do these events in permanent teeth, this trophic stimulus may begin its work early in the fetal period. Far slower is the stimulus triggering root resorption in middle childhood. A rapidly accumulating stimulus, however, controls the developmental history of the permanent mandibular central incisor, and apparently also the closely related exfoliation of its deciduous predecessor.

Supported by Research Grant D-743 (Dental), National Institutes of Health.

BENEFACTORS

Wenner-Gren Foundation
for Anthropological Research, Inc.

The Wistar Institute
of Anatomy and Biology

OFFICERS AND MEMBERS

An up-to-date listing will be published in the March, 1961 issue in connection with the proceedings of the 29th annual meeting.

Index

A

ABNORMAL hemoglobins, and hemoglobin values of pregnant women in Liberia, the blood groups . . . 1
Abnormal hemoglobins in Bornu . . . 5
A-B-O groups and M-N types. The blood groups of chimpanzees . . . 301
Adolescence: a longitudinal study, digital epiphysial fusion of the hand in . . . 13
Africans, the age at eruption of third permanent molars in male East . . . 77
Africans, the cusps on the mandibular molars of East . . . 83
Age, stature and sex of the Tepexpan remains, Mexico, revaluation of . . . 205
Agriculturists (Jarmo, Iraq), the dentition of the first . . . 243
Alleles among the Indians of the Hupa reservation, ripples on a gene-pool: the shifting frequencies of blood-type . . . 141
Allen, Fred H., Jr., and Patricia A. Corcoran. Blood groups of the Penobscot Indians . . . 109
American Association of Physical Anthropologists, proceedings of the twenty-seventh annual meeting of the . . . 327
American Association of Physical Anthropologists, proceedings of the twenty-eighth annual meeting of the . . . 353
Antigens among the Paraujano, blood group 131
Apocrine glands, XXI. The nerves around the axillary. Histology and cytochemistry of human skin . . . 69
Archaeological scaphocephal from California, an . . . 59
Arm folding, PTC sensitivity, finger prints, color vision, hand clasping, and. Genetic analysis in Russian immigrants . . . 235
Ashkenazi Jews, blood groups in . . . 201
Asmat Papuans, II. The blood groups of the. Blood group frequencies in New Guinea 189
Australian aboriginal, cranial contours in the . . . 313
Axillary apocrine glands, XXI. The nerves around the. Histology and cytochemistry of human skin . . . 69

B

Bacon, Esther. See Livingstone, Frank B. 1
Barnicot, N. A. See Spearman, R. I. . . . 91
Bekkers, Th. See Nijenhuis, L. E. . . . 189
Benton, Robert Sheeran, and James Anderson Gavan. The concept of homology applied to the anterior superior iliac spine 273
Bilaterality of human hair, a study of the . . 91
Blood factors among Koreans residing in Seoul, Korea, distribution of hereditary 115
Blood group antigens among the Paraujano 131
Blood group frequencies in New Guinea
  I. The Sentani Papuans . . . 125
  II. The blood groups of the Asmat Papuans 189
  III. Blood groups of the Nimboran Papuans . . . 193
Blood group genetical survey in New Britain, a . . . 101
Blood groups, abnormal hemoglobins, and hemoglobin values of pregnant women in Liberia, the . . . 1
Blood groups in Ashkenazi Jews . . . 201
Blood groups in Sephardic Jews . . . 193
Blood groups of chimpanzees, the. A-B-O groups and M-N types . . . 301
Blood groups of the Penobscot Indians . . . 109
Blood-type alleles among the Indians of the Hupa reservation, ripples on a gene-pool: the shifting frequencies of . . . 141
Bodily measurements in the offspring of natives of and immigrants to three Peruvian towns . . . 257
Bony centers of the hand and wrist, variability in the order of ossification of the . . . 219
Books received . . . 159
Book Review: Contributions to the physical anthropology of the Soviet Union. By V. V. Bunak, G. F. Debets and M. G. Levin. *Reviewed by* Earl W. Count . . . 322
Book Review: Evolution of the speech apparatus. By E. Lloyd du Brul. *Reviewed by* William L. Straus, Jr. . . . 325
Book Review: Methods for research in human growth. By Stanley M. Garn and Zvi Shamir. *Reviewed by* Gabriel Ward Lasker . . . 241
Book Review: The ABO blood groups. By A. E. Mourant, Ada C. Kopec and Kazimiera Domaniewska-Sobczak. *Reviewed by* Joseph B. Birdsell . . . 75
Book Review: The death of Adam. By John C. Greene. *Reviewed by* Jack Kelso . . . 242
Book Review: The ecology of human disease. By Jacques M. May. *Reviewed by* Frank B. Livingstone . . . 73
Book Review: The Puerto-Rican population. A study in human biology. By Frederick P. Thieme. *Reviewed by* Marshall T. Newman . . . 321
Book Review: The skeletal remains of Bambandyanalo. By Alexander Galloway. *Reviewed by* Ashley Montagu . . . 157
Bornu, abnormal hemoglobins in . . . 5
Boyo, A. E. See Roberts, D. F. . . . 5
Brooks, Sheilagh Thompson. See Hohenthal, William D. . . . 59

C

CALIFORNIA, an archaeological scaphocephal from . . . 59
Chagula, W. K. The age at eruption of third permanent molars in male East Africans . . . 77
Chagula, W. K. The cusps on the mandibular molars of East Africans . . . 83
Chimpanzees, the blood groups of. The A-B-O groups and M-N types . . . 301
Chronological age of the Tepexpan remains, a reevaluation of the dental status and 71
Cranial contours in the Australian aboriginal 313

Cranial fossae in closed skulls, measurement and surface features of the 97
Craniology, a functional approach to 281
Color vision, hand clasping, and arm folding, PTC sensitivity, finger prints. Genetic analysis in Russian immigrants 235
Corcoran, Patricia A. See Allen, Fred H., Jr. 109
Cusps on the mandibular molars of East Africans, the 83
Cytochemistry of human skin, histology and. XXI. The nerves around the axillary apocrine glands 69

D

DAHLBERG, Albert A. The dentition of the first agriculturists (Jarmo, Iraq) 243
Dental status and chronological age of the Tepexpan remains, a reevaluation of the 71
De Vries, J. L., and L. E. Nijenhuis. Blood group frequencies in New Guinea. I. The Sentani Papuans 125
De Vries, J. L. See Nijenhuis, L. E. ... 189, 193
Digital epiphysial fusion of the hand in adolescence: a longitudinal study 13
Du Brul, E. Lloyd, and Charles A. Reed. Skeletal evidence of speech? 153

E

ELLIS, Richard A. See Montagna, William 19, 69
Epiphysial fusion of the hand in adolescence: a longitudinal study, digital ... 13
Erskine, C. A., and C. C. C. O'Morchoe. Measurement and surface features of the cranial fossae in closed skulls 97
Eruption of third permanent molars in male East Africans, the age at 77

F

FAMILIAL study of torus palatinus and torus mandibularis, a 263
Finger and palm prints in highland and lowland Maya Indians, populational analysis of 45
Finger prints, color vision, hand clasping, and arm folding, PTC sensitivity. Genetic analysis in Russian immigrants 235
Fossae in closed skulls, measurement and surface features of the cranial 97
Freire-Maia, A., N. Freire-Maia and A. Quelce-Salgado. Genetic analysis in Russian immigrants. PTC sensitivity, finger prints, color vision, hand clasping, and arm folding 235
Freire-Maia, N. See Freire-Maia, A. 235
Functional approach to craniology, a 281
Fusion of the hand in adolescence: a longitudinal study, digital epiphysial 13

G

GAJDUSEK, D. C. See Simmons, R. T. ... 101
Garn, Stanley M., and Christabel G. Rohmann. The number of hand-wrist centers 293
Garn, Stanley M., and Christabel G. Rohmann. Variability in the order of ossification of the bony centers of the hand and wrist 219
Gavan, James Anderson. See Benton, Robert Sheeran 273
Gene-pool: the shifting frequencies of blood-type alleles among the Indians of the Hupa reservation, ripples on a 141
Genetical survey in New Britain, a blood group 101
Genetic analysis in Russian immigrants. PTC sensitivity, finger prints, color vision, hand clasping, and arm folding 235
Genoves T., Santiago. Revaluation of age, stature and sex of the Tepexpan remains, Mexico 205
Gershowitz, Henry. See Livingstone, Frank B. 1
Glands, XXI. The nerves around the axillary apocrine. Histology and cytochemistry of human skin 69
Gordon, Eve B. See Wiener, Alexander S. 301
(Greulich, William W.) Viking Fund Medalist for 1959 231
Gurevitch, J. See Margolis, E. 197, 201

H

HAIR, a study of the bilaterality of human 91
Hand and wrist, variability in the order of ossification of the bony centers of the ... 219
Hand clasping, and arm folding, PTC sensitivity, finger prints, color vision. Genetic analysis in Russian immigrants 235
Hand in adolescence: a longitudinal study, digital epiphysial fusion of the 13
Hand-wrist centers, the number of 293
Hermoni, D. See Margolis, E. 197, 201
Hemoglobins, and hemoglobin values of pregnant women in Liberia, the blood groups, abnormal 1
Hemoglobins in Bornu, abnormal 5
Hemoglobin values of pregnant women in Liberia, the blood groups, abnormal hemoglobins, and 1
Hereditary blood factors among Koreans residing in Seoul, Korea, distribution of ... 115
Histology and cytochemistry of human skin. XXI. The nerves around the axillary apocrine glands 69
Hohenthal, William D., and Sheilagh Thompson Brooks. An archaeological scaphocephal from California 59
Homology applied to the anterior superior iliac spine, the concept of 273
Hulse, Frederick S. Ripples on a gene-pool: the shifting frequencies of blood-type alleles among the Indians of the Hupa reservation 141
Human hair, a study of the bilaterality of 91
Human skin, histology and cytochemistry of. XXI. The nerves around the axillary apocrine glands 69
Hupa reservation, ripples on a gene-pool: the shifting frequencies of blood-type alleles among the Indians of the 141

I

ILIAC spine, the concept of homology applied to the anterior superior 273
Immigrants, genetic analysis in Russian. PTC sensitivity, finger prints, color vision, hand clasping, and arm folding 235
Immigrants to three Peruvian towns, variances of bodily measurements in the offspring of natives of and 257
Indians, blood groups of the Penobscot 109
Indians of the Hupa reservation, ripples on a gene-pool: the shifting frequencies of blood-type alleles among the 141
Indians, populational analysis of finger and palm prints in highland and lowland Maya 45
(–Iraq), the dentition of the first agriculturists (Jarmo,–) 243

J

(JARMO, Iraq), the dentition of the first agriculturists 243
Jews, blood groups in Ashkenazi 201
Jews, blood groups in Sephardic 197

K

KELLER, Franklin J. See Livingstone, Frank B. 1
Kim, Suk Whan. See Won, Chong Duk . . . 115
Koreans residing in Seoul, Korea, distribution of hereditary blood factors among . . 115

L

LARKIN, Lois C. See Simmons, R. T. 101
Lasker, Gabriel W. Variances of bodily measurements in the offspring of natives of and immigrants to three Peruvian towns 257
Layrisse, M., Z. Layrisse and J. Wilbert. Blood group antigens among the Paraujano 131
Layrisse, Z. See Layrisse, M. 131
Lehmann, H. See Roberts, D. F. 5
Leszczynska, Elizabeth. See Noback, Charles R. 13
Liberia, the blood groups, abnormal hemoglobins, and hemoglobin values of pregnant women in 1
Livingstone, Frank B., Henry Gershowitz, Esther Bacon, Franklin J. Keller and Abner R. Robinson. The blood groups, abnormal hemoglobins, and hemoglobin values of pregnant women in Liberia 1
Loris (*Loris tardigradus*), II. the skin of the slender. The skin of primates 19
(*Loris tardigradus*), II. the skin of the slender loris. The skin of primates 19

M

MALE East Africans, the age at eruption of third permanent molars in 77
Mandibular molars of East Africans, the cusps on the 83
Margolis, E., J. Gurevitch and D. Hermoni. Blood groups in Ashkenazi Jews 201
Margolis, E., J. Gurevitch and D. Hermoni. Blood groups in Sephardic Jews 197
Matson, G. Albin. See Won, Chong Duk . . 115
Maya Indians, populational analysis of finger and palm prints in highland and lowland 45
Measurement and surface features of the cranial fossae in closed skulls 97
Measurements in the offspring of natives of and immigrants to three Peruvian towns, variances of bodily 257
Mexico, revaluation of age, stature and sex of the Tepexpan remains 205
M-N types, A-B-O groups and. The blood groups of chimpanzees 301
Molars in male East Africans, the age at eruption of third permanent 77
Molars of East Africans, the cusps on the mandibular 83
Montagna, William and Richard A. Ellis. Histology and cytochemistry of human skin. XXI. The nerves around the axillary apocrine glands 69
Montagna, Wlliam, and Richard A. Ellis. The skin of primates. II. The skin of the slender loris (*Loris tardigradus*) . . 19
Moss, Melvin L. A reevaluation of the dental status and chronological age of the Tepexpan remains 71
Moss, Melvin L., and Richard W. Young. A functional approach to craniology . . . 281
Moss, Melvin L. See Noback, Charles R. 13

N

NATIVES or and immigrants to three Peruvian towns, variances of bodily measurements in the offspring of 257
Nerves around the axillary apocrine glands, XII. the. Histology and cytochemistry of the human skin 69
New Britain, a blood group genetical survey in 101
New Guinea, blood group frequencies in
  I. The Sentani Indians 125
  II. The blood groups of the Asmat Papuans 189
  III. Blood groups of the Nimboran Papuans 193
Newman, Marshall T. Populational analysis of finger and palm prints in highland and lowland Maya Indians 45
Nijenhuis, L. E., and J. L. De Vries. Blood group frequencies in New Guinea. III. Blood groups of the Nimboran Papuans 193
Nijenhuis, L. E. See De Vries, J. L. 125
Nijenhuis, L. E., Th. Bekkers and J. L. De Vries. Blood group frequencies in New Guinea. II. The blood groups of the Asmat Papuans 189
Nimboran Papuans, III. blood groups of the 193
Noback, Charles R., Melvin L. Moss and Elizabeth Leszczynska. Digital epiphysial fusion of the hand in adolescence: a longitudinal study 13

O

O'MORCHOE, C. C. C. See Erskine, C. A. 97
Ossification of the bony centers of the hand and wrist, variability in the order of ... 219

P

PALM prints in highland and lowland Maya Indians, populational analysis of finger and ... 45
Papuans, I. The Sentani. Blood group frequencies in New Guinea ... 125
Papuans, II. The blood groups of the Asmat. Blood group frequencies in New Guinea 189
Papuans, III. Blood groups of the Nimboran 193
Paraujano, blood group antigens among the 131
Penobscot Indians, blood groups of the ... 109
Peruvian towns, variances of bodily measurements in the offspring of natives of and immigrants to three ... 257
Populational analysis of finger and palm prints in highland and lowland Maya Indians ... 45
Pregnant women in Liberia, the blood groups, abnormal hemoglobins, and hemoglobin values of ... 1
Primates, the skin of. II. The skin of the slender loris (*Loris tardigradus*) ... 19
Proceedings of the twenty-seventh annual meeting of the American Association of Physical Anthropologists ... 327
Proceedings of the twenty-eighth annual meeting of the American Association of Physical Anthropologists ... 353
PTC sensitivity, finger prints, color vision, hand clasping, and arm folding. Genetic analysis in Russian immigrants ... 235

Q

QUELCE-SALGADO, A. See Freire-Maia, A. 235

R

RAY, L. J. Cranial contours in the Australian aboriginal ... 313
Reed, Charles A. See Du Brul, E. Lloyd .. 153
Roberts, D. F., H. Lehmann and A. E. Boyo. Abnormal hemoglobins in Bornu 5
Robinson, Abner R. See Livingstone, Frank B. ... 1
Rohmann, Christabel G. See Garn, Stanley M. ... 219, 293
Russian immigrants, genetic analysis in. PTC sensitivity, finger prints, color vision, hand clasping, and arm folding ... 235

S

SAKAI, Takuro. See Suzuki, Makoto ... 263
Scaphocephal from California, an archaeological ... 59
Sensitivity, finger prints, color vision, hand clasping, and arm folding, PTC. Genetic analysis in Russian immigrants ... 235
Sentani Papuans, I. The. Blood group frequencies in New Guinea ... 125
Seoul, Korea, distribution of hereditary blood factors among Koreans residing in 115
Sephardic Jews, blood groups in ... 197
Sex of the Tepexpan remains, Mexico, revaluation of age, stature and ... 205
Shin, Han Su. See Won, Chong Duk ... 115
Simmons, R. T., D. C. Gajdusek and Lois C. Larkin. A blood group genetical survey in New Britain ... 101
Skeletal evidence of speech? ... 153
Skin, histology and cytochemistry of human. XII. The nerves around the axillary apocrine glands ... 69
Skin of primates, the. II. The skin of the slender loris (*Loris tardigradus*) ... 19
Skin of the slender loris (*Loris tardigradus*), II. the. The skin of primates ... 19
Skulls, measurement and surface features of the cranial fossae in closed ... 97
Spearman, R. I., and N. A. Barnicot. A study of the bilaterality of human hair 91
Speech, skeletal evidence of? ... 153
Spine, the concept of homology applied to the anterior superior iliac ... 273
Stature and sex of the Tepexpan remains, Mexico, revaluation of age, ... 205
Suzuki, Makoto, and Takuro Sakai. A familial study of torus palatinus and torus mandibularis ... 263
Swanson, Jane. See Won, Chong Duk .. 115

T

TEPEXPAN remains, a reevaluation of the dental status and chronological age of the 71
Tepexpan remains, Mexico, revaluation of age, stature and sex of the ... 205
Torus mandibularis, a familial study of torus palatinus and ... 263
Torus palatinus and torus mandibularis, a familial study of ... 263

V

VARIABILITY in the order of ossification of the bony centers of the hand and wrist 219
Variances of bodily measurements in the offspring of natives of and immigrants to three Peruvian towns ... 257
Viking Fund Medalist for 1959. (William W. Greulich). By J. Lawrence Angel ... 231
Vision, hand clasping, and arm folding, PTC sensitivity, finger prints, color. Genetic analysis in Russian immigrants ... 235

W

WIENER, Alexander S., and Eve B. Gordon. The blood groups of chimpanzees. A-B-O groups and M-N types ... 301
Wilbert, J. See Layrisse, M. ... 131
Won, Chong Duk, Han Su Shin, Suk Whan Kim, Jane Swanson and G. Albin Matson. Distribution of hereditary blood factors among Koreans residing in Seoul, Korea ... 115
Wrist centers, the number of hand- ... 293

Y

YOUNG, Richard W., See Moss, Melvin L. 281